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PARACHOR AND HYDROGEN BONDING

PART III.—PARACHOR AND MOLECULAR COMPOUNDS*

By W.V.BHAGWAT and R.P. SHUKLA, *Department of Chemistry, Holkar College, Indore. M.B.*

It is well known that many organic compounds form molecular compounds(4). Thus nitro-derivatives form compounds with hydrocarbons and with amines; chloroform combines with methyl alcohol, ether, acetone and many bases. According to Lowery (5) and Bennet (2) it is very probable that in all these compounds one of the compounds acts as donor and the other as acceptor, so that a co-ordinate link is formed. In ethers, ketones and esters the oxygen atom has two lone pairs of electrons and under the influence of electron repelling groups in the same molecule, these may be donated to an appropriate acceptor. In chloroform, bromoform and iodoform the hydrogen atom apparently acts as acceptor of electrons, forming co-ordinated hydrogen. In carbon tetrachloride the chlorine appears to accept the pair of electrons from oxygen atom, this would mean that halogen can increase its outer group of electrons beyond the usual octet (3,4).

It is known that the notion of co-ordinated hydrogen is not correct and that the union is only electrostatic in nature. (6) Hence, in chloroform, bromoform and idoform union occurs through hydrogen bonding. The case of carbon tetrachloride may be treated similarly. Here also there is no increase in the covalency of chlorine, and the union between chlorine and oxygen atom may be regarded as electrostatic in nature. We have already shown that parachor measurements can be used successfully to detect the electrostatic union of hydrogen, which results in the fall in parachor value. Arguing on the same line we suggest that electrostatic union of this kind between atoms other than hydrogen should also result in the parachor defect. Clearly the value of this fall will not be constant since the strength of the bond in all cases cannot be considered to be the same. To test our views we have carried out parachor measurements by taking the two liquids concerned in the ratio of their molecular weights and finding their parachor. Our results are as follows:—

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*Parts I & II of this series were published in the *Agra Univ. J. Res.* (Sci.), **1** : 169 (1952) and **3** (1) : 1 (1954) respectively.

TABLE I

A mixture of chloroform and methyl alcohol

Wt. of CHCl	Wt. of CH_3OH	T °C	d	r	P
14.98	4.00	23.3	1.2456	22.715	265.50
		25.0	1.2431	22.308	264.91
		30.0	1.2385	22.000	264.91
29.88	8.00	23.3	1.2453	22.715	265.70
		25.0	1.2431	22.308	264.97
		30.0	1.2384	22.000	265.34
22,413	6.000	23.3	1.2458	22.688	265.40
		25.0	1.2435	22.341	265.03
		30.0	1.2380	22.008	264.91
20.917	5.600	23.3	1.2456	22.692	265.40
		25.0	1.2434	22.325	264.97
		30.0	1.2385	22.011	262.84
19.4227	5.200	23.3	1.2459	22.700	265.46
		25.0	1.2431	22.318	264.97
		30.0	1.2379	22.007	265.16
23.405	6.400	23.3	1.2456	22.688	265.34
		25.0	1.2431	22.341	265.03
		30.0	1.2387	22.008	264.91

TABLE II

A mixture of chloroform and acetone

Wt. of $CHCl_3$	Wt. of CH_3COCH_3	T °C	d	r	P
14.94	7.25	23.5	1.2621	30.318	329.99
		25.0	1.2598	29.971	329.69
		30.0	1.2554	29.524	329.61
29.88	14.50	23.5	1.2625	30.320	330.06
		25.0	1.2594	29.968	329.91
		30.0	1.2551	29.537	329.76
22.413	10.874	23.5	1.2621	30.326	329.99
		25.0	1.2598	30.000	329.99
		30.0	1.2554	29.671	330.14
20.917	10.151	23.5	1.2624	30.331	330.06
		25.0	1.2600	29.963	329.61
		30.0	1.2551	29.668	330.21
19.442	9.4254	22.5	1.2628	30.316	329.76
		25.0	1.2595	29.968	329.61
		30.0	1.2536	29.672	330.60
23.905	11.601	23.5	1.2621	30.341	330.06
		25.0	1.2598	30.004	329.69
		30.0	1.2554	29.669	330.14

TABLE III

A mixture of carbon tetrachloride and acetone

Wt. of CCl_4	Wt. of CH_3COCH_3	T °C	d	r	P
15.400	5.600	23.5	1.2431	21.483	367.21
		25.0	1.2402	21.000	365.93
		30.0	1.2351	20.761	364.83
30.801	11.600	23.5	1.2433	21.513	367.28
		25.0	1.2406	21.008	365.76
		30.0	1.2355	20.777	366.18
18.481	6.960	23.5	1.2436	21.518	357.02
		25.0	1.2405	21.011	365.76
		30.0	1.2357	20.785	360.18
20.0220	2.5405	23.5	1.2435	21.516	367.13
		25.0	1.2401	21.018	366.10
		30.0	1.2352	20.773	366.52
21.707	8.700	23.5	1.2433	21.526	367.36
		25.0	1.2404	21.026	366.10
		30.0	1.2356	20.783	366.18
23.10	8.70	23.5	1.2431	21.531	267.36
		25.0	1.2407	21.029	365.84
		30.0	1.2351	20.781	366.52

TABLE IV

A mixture of carbon tetrachloride and ethyl acetate

Wt. of CCl_4	Wt. of CH_3-CO-OC_2H_5	T °C	d		P
15.401	8.800	23.7	1.2342	21.543	422.4
		25.0	1.2317	21.002	420.66
		30.0	1.2254	20.746	421.31
16.94	9.68	23.7	1.2345	21.583	422.67
		25.0	1.2314	21.015	421.89
		30.0	1.2256	20.751	421.31
18.481	10.560	23.7	1.2344	21.583	422.67
		25.0	1.2315	21.017	420.92
		30.0	1.2251	20.764	421.70
20.022	11.44	23.7	1.2348	21.588	422.38
		25.0	1.2321	21.024	420.92
		30.0	1.2256	20.781	421.41
23.10	8.70	23.7	1.2347	21.581	422.38
		25.0	1.2318	21.023	420.63
		30.0	1.2258	20.780	421.80

DISCUSSION.—If no molecular compound is formed between the two substances, one should get the value of the parachor of mixture of two substances equal to the sum of the parachors of individual substances.

If molecular compound (or co-ordination compound) is formed, then there will be an appreciable lowering in the parachor value.

The observed value of parachor of a mixture of chloroform and methyl alcohol is 265.5 while the sum of the theoretical values of the two susbstances is 278.0 (184.4+93.2). Thus we see that there is a lowering of 12.5 units in the parachor value. Similarly, the observed values of the parachor of a mixture of chloroform in acetone, carbon tetrachloride in acetone and carbon tetrachloride in ethyl acetate are 33.0, 367.2 and 422.4, respectively. While the calculated values for the three mixtures are 345.0, 382.2 and 441.2 respectively. Thus a lowering of 15.0, 15.0 and 18.8 units respectively takes place. Hence the formation of molecular compounds in these cases should be inferred as also shown by the work of Lovery and Bannet (5.2.)

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CONDENSATION OF ETHYL ACETO-ACETATE WITH AROMATIC ALDEHYDES

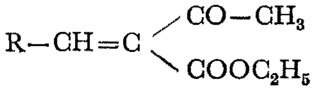
By P. P. Bagchi and P. I. Ittyerah, *Chemistry Department, St. John's College, Agra.*

The condensation of acetoacetic ester with a large number of aliphatic, aromatic and heterocyclic aldehydes has been reported by various workers (1-16). The main methods employed were (a) by passing dry HCl through a solution of a mixture of the ester and the aldehyde in alcohol, ether or ligroin, (b) by heating a mixture of the aldehyde, the ester and acetic anhydride in a sealed tube at 150°-160°C for several hours and (c) heating or keeping at room temperature or at 0°C a mixture of the aldehyde, ester and an organic or inorganic base for a number of hours.

In the chemical laboratory of St. John's College a large number of aromatic aldehydes have been condensed with ethyl aceto-acetate. The method followed has been to mix the aldehyde, ester and a condensing agent in 1:2:3 mol proportion or 1:1:3 mol proportion and to heat the mixture on water bath for several hours. The condensing agents commonly used were pyridine and 2.6 lutidine.

This paper deals with the condensation of a few aromatic aldehydes with aceto-acetic ester. The aldehydes chosen were *o*-chloro, *p*-chloro; 2:4-dichloro, 3:4-dichloro, 2:4-dichloro-3-hydroxy; 2:4:6-trichloro-3-hydroxy; 3-chloro-4-hydroxy; 3:5-dichloro-4-hydroxy, 3-bromo-4-hydroxy; 3:5-dibromo-4-hydroxy, 3:5-diiodo-4-hydroxy; 5-chloro-2-hydroxy; 3:5-dibromo-2-hydroxy; 3:5-diiodo-2-hydroxy; 5-chloro-3-nitro-2-hydroxy; 5-bromo-3-nitro-2-hydroxy; and 5-bromo-4-hydroxy-3-methoxy-benzaldehydes.

The action of ethyl aceto-acetate on benzaldehyde or substituted benzaldehyde R-CHO produces the corresponding benzal derivative (I) or the bis-ethyl-acetoacetate derivative (II) depending upon whether one or two molecules of the ester take part in the reaction. In the case of salicylic aldehyde or substituted salicylic aldehyde the product of the first type further undergoes cyclisation to 3-acetyl-coumarins.



$$\mathrm{R{-}CH{=}C}\begin{cases}\mathrm{CO{-}CH_3}\\ \mathrm{COOC_2H_5}\end{cases}$$

(I)

$$\mathrm{R{-}CH{-}[CH{-}(CO{-}CH_3){-}COO_2CH_5]_2}$$

(II)

Of the aldehydes mentioned above 5-chloro-2-hydroxybenzaldehyde and 3:5-dibromo-2-hydroxybenzaldehyde have already been condensed with ethyl acetoacetate by Miss Pandya (unpublished). The method followed by her has not been the same as followed by us. *p*-Chlorobenzaldehyde has been condensed by Knoevenagel (9) and also by Buu-Hoi, Hoan and Lavit (1) The products reported by them have been prepared and the observations are included in the table at the end for comparison. The melting point of *p*-chloro-benzal-bis-ethyl aceto-acetate as reported by Knoevenagel is 150-151°-C but we got 156°C as its melting point.

Smith (Jr.) and Kort (16) have condensed 5-bromo-vanillin with aceto-acetic ester and obtained ethyl [5-bromo-4-hydroxy-3-methoxy-benzal-]-bis-aceto-acetate. In addition to this we have also obtained the benzal derivative (I).

The method adopted for the preparation of the benzal derivative [1] was essentially the same as that recommended by Knoevenagel (9) and later by Buu-Hoi, Hoan and Lavit (1). This consisted of taking the aldehyde, ethyl acetoacetate and piperidine in 1:1:0.15 mol proportion and keeping the mixture at room temperature (approximately 20°C.) for several hours. The method adopted for the preparation of the bis ester [11] was that recommended by Smith [Jr.] and Kort (16), which consisted of taking the aldehyde, ethyl acetoacetate and piperidine in 1: 2:0.6 mol proportion and keeping the mixture at room temperature for several hours. In some cases the mixture had to be warmed a little to get the aldehyde in solution.

As is evident from the list of aldehydes mentioned before, they were mostly halogenated hydroxy aldehydes. The effect of substituent groups in the aldehyde molecule on the course of the reaction was noted. The presence of an atom or group other than the hydroxyl group at the ortho position to the aldehyde group inhibited the reaction under the observed conditions. In the case of such aldehydes only resinous matter was obtained as final products and they could not be purified. Thus *p*-chloro and 3:4-dichlorobenzaldehydes condensed well whereas *o*-chloro; and 2:4-dichlorobenzaldehydes did not condense with the ester. Similarly 2-chloro-3-hydroxy and 2:6-dichloro-3hydroxybenzaldehydes did not react whereas 3-chloro-4-hydroxy-and 5-bromo-4-hydroxy-3-methoxy; 3:5-diiodo-4-hydroxy; and 3:5-dibromo-4-hydroxy-benzaldehydes condensed well.

Halogenated salicylaldehydes were found to be very reactive, all of them gave substituted 3-acetylcoumarins. The reactivity of these aldehydes seemed to depend on the particular halogen present and was in the order I > Br > Cl. Strangely the introduction of a nitro group had an adverse effect on the reaction. Lot of resinous matter was formed and no pure product could be isolated. Perhaps a change in the experimental conditions may help in overcoming this difficulty.

3:5-diiodo-4-hydroxy and 3:5-dibromo-4-hydroxybenzaldehydes condensed well with the ester but gave only the benzal derivative (I).

Another feature noted was the formation in the case of a few aldehydes of probably a mixture of the benzal derivative (1) and the bis ester (II). They could not be separated from one another. The halogen estimation of the products gave a value intermediate between the values for the mono and the bis ester types. Their melting points in spite of repeated recrystallisations were not very sharp.

EXPERIMENTAL

The general procedure has been to mix equimolecular quantities of acetoacetic ester and the aldehyde in a small round-bottommed flask and to add piperidine in traces (0.15 mol.) to this mixture. The flask was left at room temperature for several hours. In some cases the solid product started appearing in a few minutes. In cases where the aldehydes did not go in solution in cold the mixture was gently warmed to bring it in solution and then set aside at room temperature. A few drops of the liquid from the flask were taken out and tested from time to time with dilute hydrochloric acid (1:1) and the formation of a solid mass signified the completion of the condensation. The contents were then thoroughly extracted with dilute HCl and the precipitated solid was filtered off. This was then treated with ether or cold benzene to remove any resinous matter and then recrystallised from a suitable solvent. Generally hot alcohol or benzene proved good solvents for this purpose. The products obtained were mostly of type (I).

In another set of experiments two molecules of aceto-acetic ester were taken for every molecule of the aldehyde. A larger quantity of piperidine (0.6 mol.) was also used. Extraction of the products was in the same manner as described before. Products isolated were mostly of type [II]. The salicylaldehyde derivatives gave under these conditions substituted 3-acetylcoumarins.

All the mono and bis esters were white in colour and crystalline in nature. The coumarin derivatives were high melting yellow crystalline compounds and could be recrystallised from glacial acetic acid.

Of the aldehydes mentioned in the introductory part, *o*-chloro-; 2:4-dichloro-; 2:4-dichloro-3-hydroxy- and 2:4:6-trichloro-3-hydroxy-benzaldehydes did not condense under the conditions tried. 5-Chloro-3-nitro-2-hydroxy and 5-bromo-3-nitro-2-hydroxy-benzaldehydes condensed but the product was mixed up with a lot of resinous matter and so could not be purified. 3:5-Dichloro-4-hydroxy and 3-bromo-4-hydroxy-benzaldehydes gave probably mixtures of the mono and bis type products. The remaining aldehydes gave the following products:—

1. *Ethyl-p-chlorobenzal-aceto-acetate.* This was prepared by following the method described by earlier workers (1). The yield was 90% and the melting point was 87°C.

2. *p-chloro-benzal bis-ethyl aceto-acetate.* The mixture of the aldehyde aceto-acetic ester and piperidine was kept at room temperature for 24 hours. The

yield was 54% and the melting point 156.5°C. Knoevenagel (9) and D.B. Dutta (unpublished) mention 151°C as the melting point. Found Chlorine 9.105% Calculated for $C_{19}H_{23}O_6Cl$ 9.152%.

3. *Ethyl*-[3:5-*dichloro-benzal*]-*acetoacetate.* The time required was 24 hours. The yield was 60% and it melted at 90°C. Found Chlorine 24.9%, $C_{13}H_{12}O_3Cl_2$ requires 24.72%.

4. 3:4-*Dichloro-benzal bis-ethyl-aceto-acetate.* Time taken for condensation was 12 hours. The yield was 62.3%. The substance melted at 173°C. Found Chlorine=17.02%. $C_{10}H_{22}O_6Cl_2$ requires 17.03%.

5. *Ethyl*-[3-*chloro*-4-*hydroxy-benzal*]-*aceto-acetate.* Time required was 24 hours. Yield was 86% and melting point 85° C. Found: Cl, 13.39 %; $C_{13}H_{13}O_4Cl$ requires 13.22 %.

6. 3-*Chloro*-4-*hydroxy-benzal-bis-ethylaceto-acetate.* It melted at 188° C. The yield was only 31.3 per cent. Found: Cl, 9.177% $C_{10}H_{23}O_7Cl$ requires Cl, 8.908.

7. *Ethyl*-[3:5-*diiodo*-4-*hydroxy-benzal*]-*aceto-acetate.* Yield 67 per cent. It melted at 120° C. Found: I, 52.2%; $C_{13}H_{12}O_4I_2$ requires 1,52.26%.

8. *Ethyl*-[3:5-*dibromo*-4-*hydroxy-benzal*]-*aceto-acetate.* Yield 50%. It melted at 112° C. Found: Br, 40.17 %: $C_{12}H_{12}O_4Br_2$ requires Br, 40.82%.

9. *Ethyl*-[5-*bromo*-4-*hydroxy*-3-*methoxy-benzal*]-*aceto*-*acetate.* Time taken was 24 hours and the yield was 88.2 per cent. It melted at 140° C. Found: Br, 23. 04%, $C_{14}H_{15}O_5$ Br requires Br, 23.32 %.

10. 5-*bromo*-4-*hydroxy*-3-*methoxy-benzal-bis-ethyl aceto-acetate.* The yield even after keeping for 90 hours was only 34 per cent. M.P. 186 C. Smith [Jr]. and Kort (16) report the same melting point.

11. 6-*Chloro*-3-*acetyl-coumarin.* Time taken was 12 hours and the yield obtained was 40%. It melted at 208° C. Found: Cl, 15.66 %, Calculated for $C_{11}H_7O_5Cl$, 15.95%. Miss Pandya (unpublished) has prepared the same substance using 2:6-lutidine as condensing agent.

12. 6:8-*Dibromo*-3-*acetyl-coumarin*. Time taken was 12 hours and the yield obtained was 60%. Melting point 223.5° C. Found: Br, 45.88%, Calculated for $C_{11}H_6O_3$ Br_2, 46.24%. This compound was prepared earlier in this laboratory by Miss Pandya [unpublished].

13. 6:8-*Diiodo*-3-*acetyl-coumarin.* The condensation took place in 12 hours and the yield was 90%. M.p. 263° C. Found I, 57.23%, $C_{11}H_6O_3I_2$ requires I, 57.72%.

SUMMARY

Ethyl aceto-acetate was condensed with several aromatic aldehydes in presence of a trace of piperidine. The reactions were carried out at room temperature. The aldehydes select-

ed were, *o*-chloro-, *p*-choloro-, 2:4-dichloro-, 3:4-dichloro-, 2:4-dichloro-3-hydroxy-, 2:4:6-trichloro-3-hydroxy-, 3-chloro-4-hydroxy-, 3:5-dichloro-4-hydroxy-, 3-bromo-4-hydroxy-, 3:5-dibromo-4-hydroxy-, 3:5-diiodo-4-hydroxy-, 5-chloro-2-hydroxy-, 3:5-dibromo-2-hydroxy-, 3:5-diiodo-2-hydroxy-, 5-chloro-3-nitro-2-hydroxy-, 5-bromo-3-nitro-2-hydroxy-, and 5-bromo-4-hydroxy-3-methoxy benzaldehydes. The observations made regarding the influence of substituent groups in the aldehyde molecule on the course of the reactions are reported. The isolation, purification and analysis of the condensation products are described.

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APPLICATION OF CHROMOUS SALT SOLUTIONS

By R.C. Rai, M.Sc., D.Phil., Uttam Chand, M.Sc., *St. John's College*,
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Traube and Parasarge (1) reported that chromous salts are very powerful reducing agents. Dimroth and Frister (2) used chromous chloride solution for titrating γ,γ' 'dipyridyl and found it to be suited for titration and scarcely changing its titer value with time, provided it is properly stored and used. Later Buehrer and Schupp (3) published the results of experiments, in which they used chromous chloride as a directly standard titer for (potentiometric) determinations. Zintl and his various collaborators (4) studied the use of chromous solutions for the direct potentiometric titration of single heavy metals and of several metals in the presence of each other. Later on Brintzinger and his co-workers (5) made an extensive study of the potentiometric application of chromous salts. Rienacker and Schloffer (6) estimated Cr, Cu, Hg, Ag, Bi and Au etc. potentimetrically and during these estimations observed that certain salts were reduced to their metallic states.

In this paper we have made an investigation on a new line to separate the basic constituents of a mixture of salt solutions by the help of chromous salt solution. When a chromous salt solution is added to a salt solution and if the reduced ion goes to its metallic state and the metal is obtained in fine state of subdivision, then the addition of some flocculating agent becomes necessary to precipitate the metal in the form of bigger granules. Starch solution has been used as a flocculating agent in most of these cases.

The addition of chromous sulphate solution to a copper salt solution causes the reduction of cupric ion to cuprous state and finally to metallic copper. Similarly a Ag salt solution is reduced to metallic silver state. If to a mixture of copper-cadmium and silver-cadmium solutions, chromous sulphate is added, it precipitates metallic copper in first case and metallic silver in second case while cadmium remains unaffected. Hence a quantitative separation of silver-cadmium and copper-cadmium has been done in different acidic media.

Preparation and Stability of Chromous salt solution

Traube, Burmeister and Stahn (8) as well as Asmanow (9) prepared chromous salt solution by reducing the chromic salt electrolytically. K Someya (10) obtained it by using reducing agents like amalgams of Zn, Pb, etc. Due to higher susceptibility of atmospheric oxidation, chromous salt solutions are stored in an atmosphere of purified hydrogen or CO_2.

During this investigation chromous sulphate solution was prepared by reducing an acidified (sulphuric acid) solution of potassium chrome alum by means of amalgamated zinc in a Jones reductor (This unit permits reduction of a solution by retaining it in a column of an amalgamated zinc for the required time. Zinc was amalgamated by first cleaning it with HCl and adding 10% of mercuric chloride solution to the mixture with stirring until the zinc is well covered with mercury). The solution was kept in an atmosphere of pure hydrogen. After three or four hours sky blue colour of chromous ion is visible and this reduced solution was used as a precipitant.

EXPERIMENTAL

Potash chrome solution of strength M/10 approx. was prepared and transferred to a reducing column; 4-5cc of conc. sulphuric acid was added and kept in an atmosphere of purified hydrogen. This hydrogen was purified by passing it through acidified potassium permanganate and chromous chloride solutions. N/10 solutions of $AgNO_3$, $CuSO_4.5H_2O$ and $3CdSO_4.8H_2O$ were prepared.

Estimation of Metallic Silver from Silver Nitrate solution by Chromous Sulphate Solution.

Two Erlenmeyer flasks containing each 25 cc of silver nitrate solution of strength ·1105N were taken. 10cc of 2N acetic acid was added in each. They were diluted and warmed to 40°C approx. In one flask 5cc of starch solution (flocculating agent) was added. Chromous sulphate solution was added drop by drop to these solutions till $AgNO_3$ was completely reduced to metallic silver. During the course of operation the solutions were stirred vigorously. After the complete precipitation it was filtered.

The precipitate was washed with cold water two or three times. Later it was dissolved in dilute nitric acid and silver was estimated by Volhard's method.

Similar experiments were done in the presence of 2N sulphuric acid instead of CH_3COOH.

The results are given in the following table.

TABLE I

Reduction of silver nitrate in the presence of 2N acetic and sulphuric acids

Volume of $AgNO_3$ Solution	Volume of acid	Volume of starch solution	Volume of chromous sulphate solution	Percentage of reduction
25.00 C.C.	10.00 C.C. [Acetic]	0.00 C.C.	60.00 C.C.	99.5 %
25.00 C.C.	10.00 C.C. [Acetic]	5.00 C.C.	60.00 C.C.	100 %
25.00 C.C.	10.00 C.C. [Sulphuric]	0.00 C.C.	60.00 C.C.	99.22 %
25.00 C.C.	10.00 C.C. [Sulphuric]	5.00 C.C.	60.00 C.C.	99.75 %

From the perusal of the above table it is quite clear that the solutions in which starch was added, the results closely agree with the theoretical value.

Separation of Silver and Cadmium by Chromous Sulphate Solution.

Various mixtures of Ag NO_3 of strength. ·1105N and cadmium sulphate of strength ·0998N were taken. Estimations were done in the presence of 2N acetic acid and in 2N sulphuric acid. Chromous sulphate solution was added in the solutions till the reduction was complete. It was filtered and the filterate containing cadmium was estimated as cadmium sulphide, and silver was estimated by Volhard's methods as done above.

TABLE II

Volume of $AgNO_3$	Volume of $CdSO_4$	Volume of acid	Volume of starch solution	Volume of chromous sulphate solution	Percentage of Ag	Percentage of Cd.
10.00 C.C.	10.00 C.C.	5.00 C.C. [Acetic]	5.00 C.C.	30.00 C.C.	99.75 %	99.5 %
10.00 C.C.	10.00 C.C.	5.00 C.C. [Sulphuric]	5.00 C.C.	30.00 C.C.	100 %	99.45 %
10.00 C.C.	20.00 C.C.	5.00 C.C. [Acetic]	5.00 C.C.	30.00 C.C.	99.5 %	99.7 %
10.00 C.C.	20.00 C.C.	5.00 C.C. [Sulphuric]	5.00 C.C.	30.00 C.C.	100 %	99.89 %

These results in the above table show that the separation of silver and cadmium is quantitative within experimental error.

Estimation of Metallic Copper from Copper Sulphate solution by Chromous Sulphate Solution.

Three Erlenmeyers flasks were taken and 10cc of copper sulphate solution of strength ·1056N was taken in each. In one flask acetic acid, in second HCl and in third H_2SO_4 was added. The solutions were diluted and heated to 80° C for 5 minutes. In a hot solution, chromous sulphate solution was added till complete reduction was done. During the course of reduction, copper sulphate solutions were stirred. Metallic copper was obtained in a fine state. This was filtered and washed with cold water two or three times. Later the precipitate was dissolved in dilute HNO_3. Nitric acid was then removed by H_2SO_4 and copper was estimated iodometrically after neutralising the acidity with sodium carbonate and making the solution acidic with acetic acid. The results are given in the following table:—

TABLE III

Reduction of copper sulphate soultion in presence of 2N acetic acid, HCl and H_2SO_4 acid

Volume of copper sulphate solution	Volume of acid	Volume of chromous sulphate solution	Percentage of reduction
10.00 C.C.	5.0 C.C. [Acetic]	25.00 C.C.	99.5 %
10.00 C.C.	5.0 C.C. [Hydrochloric]	25.00 C.C.	99.47 %
10.00 C.C.	5.0 C.C. [Sulphuric]	25.00 C.C.	99.74 %

The following estimations were done in the presence of 5cc of 1% starch solution.

TABLE IV

Volume of copper sulphate solution	Volume of acid	Volume of chromous sulphate solution	Percentage reduction
10.00 C.C.	5.00 C.C. [Acetic]	30.00 C.C.	99.74 %
10.00 C.C.	5.00 C.C. [Hydrochloric]	30.00 C.C.	99.74 %
10.00 C.C.	5.00 C.C. [Sulphuric]	30.00 C.C.	100 %

The solutions, in which starch is added, show that the results are much nearer to the theoretical value.

Separation of Copper and Cadmium by Chromous Sulphate Solution

Various mixtures of copper sulphate solution of strength ·1056N and cadmium sulphate solution of strength ·0998N were taken. Copper was precipitated and estimated as before and in the filtrate cadmium was estimated as cadmium sulphide.

TABLE V

Volume of $CuSO_4$ solution	Volume of cadmium sulphate solution	Volume of acid	Volume of chromous sulphate solution	Volume of starch	Percentage of copper	Percentage of cadmium
10.0 C.C.	10.0 C.C.	5.00 C.C. [Acetic]	35.00 C.C.	5.00 C.C.	99.5 %	99.4 %
10.0 C.C.	10.0 C.C.	5.00 C.C. [Hydrochloric]	35.00 C.C.	5.00 C.C.	99.74 %	99.8 %
10.0 C.C.	10.0 C.C.	5.00 C.C. [Sulphuric]	35.00 C.C.	5.00 C.C.	100 %	99.3 %
10.0 C.C.	20.00 C.C.	5.00 C.C. [Acetic]	35.00 C.C.	5.00 C.C.	99.74 %	99.3 %
10.0 C.C.	20.00 C.C.	5.00 C.C. [Hydrochloric]	35.00 C.C.	5.00 C.C.	99.50 %	99.5 %
10.0 C.C.	20.00 C.C.	5.00 C.C. [Sulphuric]	35.00 C.C.	5.00 C.C.	99.74 %	99.2 %

Conclusion.—Estimation of silver, copper and separation of silver-cadmium copper-cadmium is satisfactory and are within experimental error.

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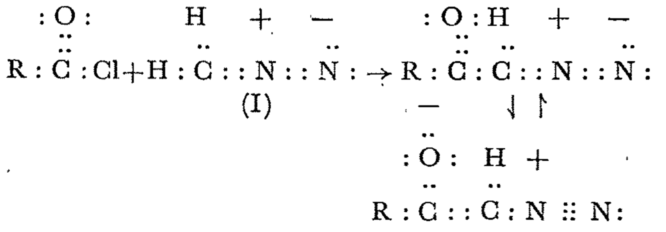
REACTION OF SODIUM AZIDE WITH ACID CHLORIDES

By P.D. GOYAL and OM PRAKASH SAXENA

The reaction between sodium azide and three inorganic acid chlorides, namely (1) iodine monochloride (2) nitrosyl chloride and (3) chromyl chloride has been observed separately. An effort has been made to explain the behaviour of the reaction product in the light of its electronic structure.

"The instability of diazomethane (I) is due to the existence of opposite polarities on the two nitrogen atoms. The diazoketones (II) are more stable, because the negative polarity is now centered upon an oxygen atom, and also because the poles are now separated by two other atoms." [Summary of lecture by S.S. Deshpande; *Journal of the Royal Institute of Chemistry, London,* (1953), 77, 438].

The diazoketones (II) are formed from carboxylic acid chloride and diazomethane (I)



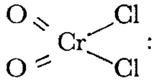
$$R:\overset{:O:}{\underset{}{C}}:Cl + H:\overset{H}{\ddot{C}}::\overset{+}{N}::\overset{-}{\ddot{N}}: \rightarrow R:\overset{:O:}{C}:\overset{H}{\ddot{C}}::\overset{+}{N}::\overset{-}{\ddot{N}}: \qquad (I)$$

(I)

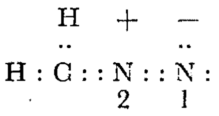
$$\downarrow\uparrow$$

$$R:\overset{:\overset{-}{\ddot{O}}:}{\ddot{C}}::\overset{H}{\ddot{C}}:\overset{+}{N}\vdots\vdots N: \qquad (II)$$

Each of the components taking part in the formation of diazoketone (II) in the above reaction is an organic molecule. It is possible that if these components are replaced by inorganic molecules, without changing the type, the general course of the reaction will not be altered. If this happens it will be interesting to observe how the reaction product compares with diazoketone (II) in regard to its stability. The present paper describes observations made with this object in view.

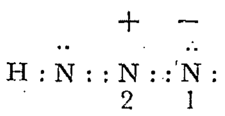
The carboxylic acid chlorides in equation (I) may be replaced by chlorides of inorganic oxyacids. We chose for this purpose (i) iodine monochloride I Cl (chloride of hypoiodous acid IOH) (ii) nitrosyl chloride O=N-Cl and (III) chromyl chloride  : These chlorides contain zero, one and two oxygen atoms respectively.

For an inorganic molecule retaining the type of diazomethane (I) we chose hydrazoic acid (III) which contains in its molecule nitrogen atoms 1 and 2, in the same strained condition as in diazomethane. Hydrazoic acid can be visualised as being produced from diazomethane by replacing its 4-covalent carbon by 3-covalent nitrogen. The sodium salt of the acid is more convenient than the acid itself. It contains the anion (IIIa) having most symmetrical electron distribution.



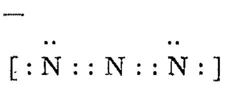
$$H:\overset{H}{C}::\overset{+}{\underset{2}{\ddot{N}}}::\overset{-}{\underset{1}{\ddot{N}}}:$$

(I)



$$H:\ddot{N}::\overset{+}{\underset{2}{N}}::\overset{-}{\underset{1}{\ddot{N}}}:$$

(III)



$$\overset{-}{[:\ddot{N}::N::\ddot{N}:]}$$

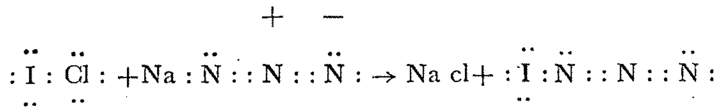
(IIIa)

The reaction between carboxylic acid chlorides and diazomethane is slow, being a reaction between molecules. Sometimes more than two days are required for its completion. In contrast to this the reaction between sodium azide and acid chlorides is expected to be fast, as the former is ionised, giving the ion (IIIa). This expectation was fully realised; the reaction being complete generally in a few minutes. The inducement of the reaction between inorganic acid chlorides and sodium azide will be for the purpose of relieving the strain on nitrogen atoms 1 and 2 in (III), or (IIIa).

When iodine monochloride and sodium azide in molecular proportion in suspension in carbon tetrachloride were brought together at 0°C, reaction immediately took place: The reaction products were identified as nitrogen, iodine and sodium chloride. The nitrogen was collected in a Lunge nitrometer and was measured. The iodine and sodium chloride were quantitatively estimated. It was found that the proportion between the reactants and the resultants are given by the following equations.

$$2\ I\ Cl+2\ Na\ N_3=3\ N_2+I_2+2\ NaCl \qquad (2)$$

It therefore follows that either the expected iodoazide (IV) is not formed, or if it was formed, it decomposed into nitrogen and iodine.



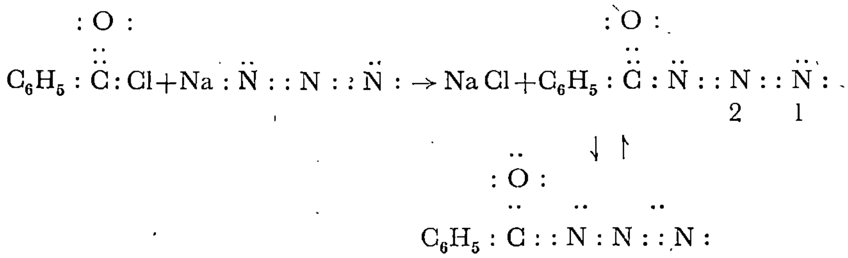
$$:\underset{..}{\ddot{I}}:\underset{..}{\ddot{Cl}}:+Na:\ddot{N}::\overset{+}{N}::\overset{-}{\ddot{N}}:\rightarrow Na\,cl+:\underset{..}{\ddot{I}}:\ddot{N}::N::\ddot{N}:$$

(IV)

Iodoazide (IV) is described by Hantzsch [Ber. (1900) 33 : 522] as an explosive pale yellow solid obtained by the action of iodine on silver azide at 0°C. In non-aqueous solvents it slowly decomposes into iodine and nitrogen. Since the reaction between iodine monochloride and silver azide, which we carried out at 0°C proceeded smoothly forming sodium chloride, iodine and nitrogen, it appears that iodoazide is probably formed as an intermediate. It is not easy at this stage to speculate about the mechanism of this reaction without more experimental data.

Iodine monochloride is not however a true representative of inorganic oxyacid chlorides for our purpose as it contains no oxygen. The nitrosyl chloride and chromyl chloride, whose action we are going to describe are the true representatives.

Although the object is to replace the diazomethane in equation (I) by hydrazoic acid (or sodium azide) and the carboxylic acid chloride by inorganic acid chloride containing oxygen, it is advantageous to examine first an intermediate case in which the carboxylic acid chloride remains, and only the diazomethane is replaced by hydrazoic acid. Such a reaction has been studied by Curtius who has also studied the behaviour of the reaction product. For instance benzoyl chloride and sodium azide give benzoyl azide (V) (Curtius)

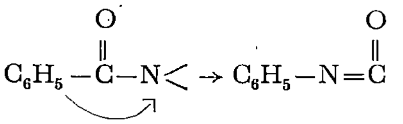


$$C_6H_5:\overset{\overset{:O:}{\cdot\cdot}}{C}:Cl+Na:\ddot{N}::N::\ddot{N}:\rightarrow NaCl+C_6H_5:\overset{\overset{:O:}{\cdot\cdot}}{C}:\ddot{N}::\underset{2}{N}::\underset{1}{\ddot{N}}: \qquad (V)$$

$$\downarrow\uparrow$$

$$C_6H_5:\overset{\overset{\cdot\cdot}{:O:}}{\underset{}{\overset{\cdot\cdot}{C}}}::\ddot{N}:\ddot{N}::N: \qquad (Va)$$

The strain on the contiguous nitrogen atoms 1 and 2 in (V) due to opposite polarities on them, is relieved by electromeric displacement to (Va) which becomes possible on account of the oxygen atom which can accept negative charge. (V) also undergoes thermal decomposition with loss of nitrogen molecule formed from the strained nitrogen atoms. The residual radical $C_6H_5-\overset{\overset{O}{\|}}{C}-N<$ then stabilises by undergoing rearrangement to phenylthio cyanate (VI).



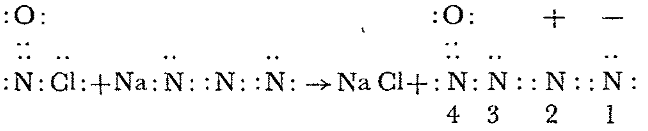
$$C_6H_5-\overset{\overset{O}{\|}}{C}-N<\rightarrow C_6H_5-N=\overset{\overset{O}{\|}}{C} \qquad (VI)$$

If now the carboxylic acid chloride is also replaced by inorganic oxyacid chloride (containing oxygen) a compound similar to (V) or (Va) is expected to be formed. The possibility of its further decomposition with loss of nitrogen will depend upon the electronic condition in the resulting molecule.

When a saturated ethereal solution of nitrosyl chloride gas was added to a suspension of sodium azide in dry ether at temperatures below 0°C a reaction took place. The products of the reaction were identified as sodium chloride, nitrous oxide and nitrogen. The proportion between the two gases was determined by taking advantage of the fact that nitrous oxide dissolves in absolute alcohol, while nitrogen does not. It was then found that the two gases were in equimolecular proportion. The overall reaction is given by the equation.

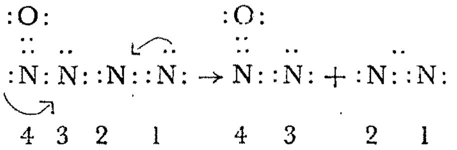
$$O=N-Cl+NaN_3=Na\,Cl+N_2O+N_2 \qquad (3)$$

The formation of nitrous oxide containing two atoms of nitrogen from nitrosyl chloride which contains only one atom of nitrogen clearly indicates that the reaction did take place on the same lines as in the case of benzoyl chloride and sodium azide.



$$\overset{\overset{:O:}{\cdot\cdot}}{:N}:\overset{\cdot\cdot}{Cl}:+Na:\overset{\cdot\cdot}{N}::N::\overset{\cdot\cdot}{N}:\rightarrow NaCl+:\underset{4}{\overset{\overset{:O:}{\cdot\cdot}}{N}}:\underset{3}{\overset{\cdot\cdot}{N}}::\underset{2}{\overset{+}{N}}::\underset{1}{\overset{-}{\overset{\cdot\cdot}{N}}}: \qquad (VII)$$

The nitrosyl azide (VII) however differs from benzoyl azide (V) in the nature of products of its further decomposition. Whereas the latter loses nitrogen and forms a radical which can stabilise itself only by rearrangement to (VI), the former loses nitrogen leaving behind a full molecule of nitrous oxide. The circumstance that the nitrogen atom 4 in (VII) has a lone pair of electrons (which the carbon in (V) has not) enables transfer of this lone pair to the place between this nitrogen and the neighbouring one (3). This electromeric change results in the cleavage of (VII) into nitrogen molecule and nitrous oxide molecule.



$$\underset{4}{\overset{\overset{:O:}{\cdot\cdot}}{:N}}:\underset{3}{\overset{\cdot\cdot}{N}}::\underset{2}{N}::\underset{1}{\overset{\cdot\cdot}{N}}:\rightarrow \underset{4}{\overset{\overset{:O:}{\cdot\cdot}}{N}}::\underset{3}{\overset{\cdot\cdot}{N}}:+:\underset{2}{N}::\underset{1}{\overset{\cdot\cdot}{N}}:$$

Nitrosyl azide Nitrous oxide Nitrogen

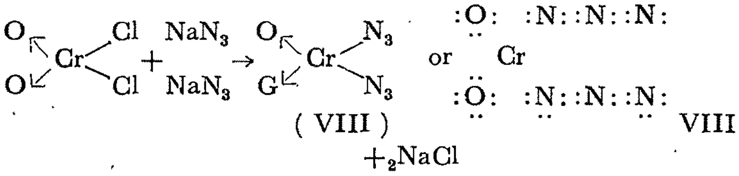
The electronic structure of nitrous oxide as shown above is well established [Langmuir *Am. Chem. Soc.* (1919) 41, 897, Pauling, *Proc. Nat. Acad. Sci.* (1932), 18 294, 498].

It is interesting to observe that the distribution of electrons in nitrous oxide is the same as in azide anion which probably accounts for the comparative stability of the former.

$[:\overset{\cdot\cdot}{N}::N::\overset{\cdot\cdot}{N}:]$ azide anion $\qquad$ $:\overset{\cdot\cdot}{O}::N::\overset{\cdot\cdot}{N}:$ nitrous oxide

Pure chromyl chloride and pure dry sodium azide were observed to react with one another with explosive violence. The vigour of the reaction was moderated by using carbon tetrachloride as diluant and by working at temperature below 0°C. There was no effervescence indicating that no gaseous product was formed. The reaction is exothermic. The solid and liquid constituents of the reaction mixture were separated by filtration. The liquid boiled at 78°C and proved to be nothing but solvent itself. Hence the reaction product could not be a gas or a liquid and can only be a solid. Also sodium chloride must be formed as in the previous cases. Besides there could be some unchanged sodium azide. The separation of the solid reaction product from sodium chloride and sodium azide proved to be difficult. It was however found that on shaking the solid mixture with absolute alcohol the reaction product went into solution leaving behind the other two solids. On cautious evaporation of the alcoholic solution at room temperature a dark brown green crystalline mass was left. This contains chromium. In contact with water or dilute acids it undergoes slow hydrolysis and produces finally a green solution. The presence of nitrogen in the product could be observed only qualitatively. In its reaction with dilute hydrochloric acid a gas was evolved which was collected over water. It was inert, neutral, non-combustible and a non supporter of combustion. It was inferred that the gas was nitrogen. Experiments on the estimation of nitrogen in the form of ammonia by reducing the solid product with zinc dust or on its catalytic decomposition by means of platinum black were unsuccessful.

The solid reaction product could not be purified by crystallisation from alcohol. Estimation of chromium in the fairly pure solid gave the value 33.2 per cent. The chromium in the chronyl azide (VIII)(Cr O_2 $(N_3)_2$) should be 32 per cent.



The oxygen atoms in chromyl chloride and therefore also in chromyl azide are bound to chromium atom with co-ordinate links, the negative charge being upon oxygen. The condition of oxygen in (VIII) is thus different from what it is in benzoyl azide (V) or nitrosyl azide (VI). Further there is no lone pair of electrons on chromium atom. Therefore neither the type of electromeric change which benzoyl azide can undergo nor that which nitrosyl azide undergoes is possible in the case of chromyl azide.

EXPERIMENTAL

Preparation of acid chlorides:—

(i) Iodine monochloride.—Pure dry chlorine gas was passed over powdered iodine until liquifaction took place. The crude liquid iodine mono chloride was purified by distillation over some powdered iodine. The fraction boiling at 100°-102°C was collected.

(ii) Nitrosyl chloride.—By distilling a mixture of one volume of concentrated nitric acid and four volumes of strong hydrochloric acid a gaseous mixture of chlorine and nitrosyl chloride was produced.

$$HNO_3+3H\,Cl=Cl_2+NOCl+2H_2O$$

The mixture of the gases was dried over anhydrous calcium chloride and then was bubbled through concentrated sulphuric acid kept surrounded by

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freezing mixture. Nitrosyl chloride alone was absorbed, while chlorine passed on. The bubbling was continued till the sulphuric acid was saturated with the gas which converted it into nitroso sulphuric acid with a deep yellow colour.

$$SO_2(OH)_2+NOCl=SO_2(OH)\ (O-N=O)+HCl.$$

The nitroso sulphuric acid was then decomposed by warming it with pure dry powdered sodium chloride.

$$SO_2(OH)\ (O-N=O)+Na\ Cl=SO_2(OH)\ (ONa)+NOCl.$$

Attempts to condense nitrosyl chloride gas by passing it through a coiled condenser cooled by freezing mixture were unsuccessful. The gas was therefore absorbed in dry ether kept cool by freezing mixture, till a deep yellow saturated ethereal solution was obtained.

(iii) Chromyl chloride.—This was prepared by distilling a mixture of potassium dichromate, common salt and sulphuric acid. The orange gas cooled to an orange liquid. This was further purified by distillation (B. p. 117° C) and stored in glass stoppered bottle.

The reaction—(i) Iodine monochloride and sodium azide: The reaction was carried out in carbon tertrachloride at freezing temperature. A conical flask contained a suspension of a known weight of sodium azide in dry carbon tetrachloride. A test tube containing excess of iodine monochloride dissolved in the same solvent stood in the flask resting against its wall. The flask was fitted with a stopper and an exit tube which was connected, through pressure tubing to the measuring tube of a Lunge nitrometer. On tilting the flask the contents of the test tube came in contact with the sodium azide suspension, and the nitrogen evolved displaced equal volume of air which was collected in the measuring tube of the nitrometer. 0.0486 gm. of sodium azide gave 29 C. C. of nitrogen (moist) at 25° C and 748 m.m. pressure. (tension of aqueous vapour 24 m.m.) (Found N=0.0316 gm. Equation (2) requires N=0.0314 gm.)

For estimation of sodium chloride formed in the reaction the experiment was repeated using excess of iodine monochloride and allowing the nitrogen to escape. The sodium chloride was removed by filtration, washed with carbon tetra chloride, dried and estimated by dissolving in water and precipitating as silver chloride. (Found 0.0900 gm. of sodium azide gave NaCl corresponding to 0.1946 gm. of Agcl. Equation (2) requires 0.1954 gm. of AgCl.)

The iodine produced in the reaction could not be correctly estimated as it was mixed up with excess of iodine monochloride in carbon tetrachloride solution. When however from the filtrate the solvent and the excess of iodine monochloride were cautiously removed by evaporation the residual solid was found to be pure iodine.

(ii) Nitrosyl chloride and sodium azide.—The reaction was carried out by addition of saturated ethereal solution of nitrosyl chloride to ethereal suspension of sodium azide kept at freezing temperature. As in the case of the previous reaction independent experiments were performed for estimation of sodium chloride, and of the gaseous products of reaction. For completion of reaction sufficient excess of nitrosyl chloride was used, which was indicated by permanent pale yellow colour of the ether layer. The sodium chloride was estimated as in the previous case. (Found 0.1360 gm. sodium azide gave NaCl corresponding to 0.2998 gm. of AgCl. Equation (1) requires 0.3001 gm. of AgCl.

The proportion of nitrous oxide in the gaseous mixture evolved was established as follows. The air in the reaction flask was first allowed to be displaced by the evolved gaseous mixture, which was then collected in a graduated inverted tube over water, until the tube was full. It was then closed and inverted over absolute alcohol. After allowing some alcohol to enter (due to absorption of some nitrous oxide) the tube was closed again and the gaseous mixture was thoroughly shaken with the entered alcohol. On inverting over alcohol again the latter entered and nearly half filled the tube indicating that nearly half of the mixture consisted of nitrous oxide. The residual gas proved to be nitrogen.

The absorption of nitrous oxide in absolute alcohol is not 100 per cent. In an independent experiment 25 c.c. of pure nitrous oxide prepared from sodium nitrate and ammonium sulphate was collected over brine. On shaking repeatedly with absolute alcohol 23 c.c. of the gas was absorbed. The absorption percentage was therefore $\frac{23 \times 100}{25} = 92$. Now when 25 c.c. of the gaseous mixture evolved in the reaction was similarly treated with absolute alcohol the absorption was found to be 11 c.c. Hence the volume of nitrous oxide in the mixture must be $\frac{11 \times 100}{92} = 12$ c.c. which is almost half of the total volume of the mixture.

(iii) Chromyl chloride and sodium azide.—Chromyl chloride in sufficient excess dissolved in carbon tetrachloride was added slowly to a suspension of sodium azide in the same medium kept at freezing temperature. Unlike the two previous cases no gas was evolved in this case. The reaction was exothermic and was comparatively much slower. The liquid and the solid after completion of reaction were separated by filtration. The former was found to be almost pure solvent and on distillation or evaporation left no appreciable residue. Hence the products of reaction were only in the solid.

The solid was slowly attacked by water in which it dissolved producing a green solution. Probably this was some sort of hydrolysis. On shaking with cold absolute alcohol, part of the solid dissolved. The residue after washing with absolute alcohol was identified as sodium chloride. No attempt was made at its quantitative estimation.

The alcoholic solution on evaporation left a dark green brown crystalline mass. This could not be further purified by crystallisation from the same solvent.

When fresh the product dissolved in water or absolute alcohol giving green solution, but after standing for some days it becomes insoluble in these solvents. It is decomposed by dilute mineral acids and also acetic acid. The gas evolved in its reaction with hydrochloric acid was identified as nitrogen. The expectation that on its fusion with zinc dust and caustic soda the nitrogen would appear as ammonia was not realised. Attempt at catalytic decomposition of the compound with platinum black in weak acid medium was also unsuccessful.

The chromium of the compound was estimated volumetrically as potassium dichromate. The chromium was found to be 33.2 per cent. Gravimetric estimation gave the result 33.8 per cent. Chromyl azide Cro_2 $(N_3)_2$ (VIII) requires chromium to be 32 per cent.

EFFECT OF FAT ON MINERALISATION OF NITROGEN IN SOME OIL-CAKES & WOOL-WASTE

By PURNA CHANDRA & J.G. SHRIKHANDE, *Agricultural College, Kanpur.*

The use of oil-cakes as manure has been in vogue for centuries in China and Japan (8). Considerable emphasis on its use was laid by the Royal Commission on Agriculture in India (13). Oil-cakes are rich in nitrogen and contain a fair amount of potash and phosphorus. The edible oil-cakes are used as cattle feed and the non-edible varieties of cakes are used as manures (15). A fair amount of fat is left in oil-cakes after oil-extraction. The presence of this residual fat and the nature of the plant material affect the decomposition (16). An attempt was thus made to study the decomposition of oil-cakes from these points of view and also to determine the limits of fat within which satisfactory decomposition occurs.

A review of the literature indicated that a detailed investigation of these points was necessary in spite of the various tests on the availability of nitrogen in some oil-cakes by Bal & Plyman (1, 2), Rao (11), Hutchinson (6), Fowler (5), Rege (12), Walton (17), Joshi (7), Pal & Rakshit (10). The delayed nitrification of *mahua* oil cake was studied by Fowler (5) who found that saponin was responsible for inhibition in nitrification up to a certain period. Similar observations were noted by Shrikhande (14) with this cake and he explained that mowerine in *mahua* cake delayed its nitrification because mowerine is toxic to the micro-organisms. According to Das (4) the delay in nitrification of apricot seed cake was due to the presence of hydrocynic acid.

The study of wool-waste as manure was conducted at Rothamstead for 60 years (1852-1911) and it was found that it is quite suitable as manure for farm crops with a marked residual effect. Since the effect of fat content on the decomposition of wool-waste has not been investigated properly it was considered desirable to include wool waste also in this investigation.

PLAN OF INVESTIGATION

The study was conducted in pots and flasks in duplicate. The inner surface of the pot was coated with a thick layer of paraffin wax so as to prevent seepage of the water-soluble salts through the pores. Control experiments were also run in duplicate with the same soil.

Percentage of nitrogen in Cakes & Wool-Waste

1.	Castor (*Ricinus communis*) Cake	4.6
2.	Neem (*Melia azadirecta*) Cake	7.1
3.	Mahua (*Bassia latifolia*) Cake	2.9
4.	Wool Waste	12.5

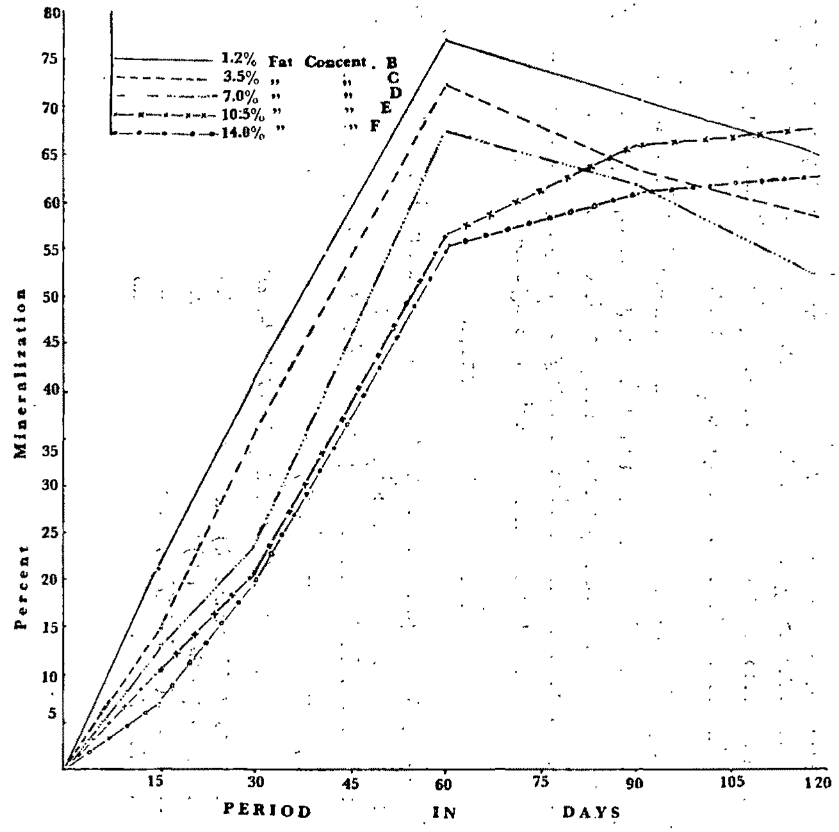

FIG. 1. Castor oil-cake.

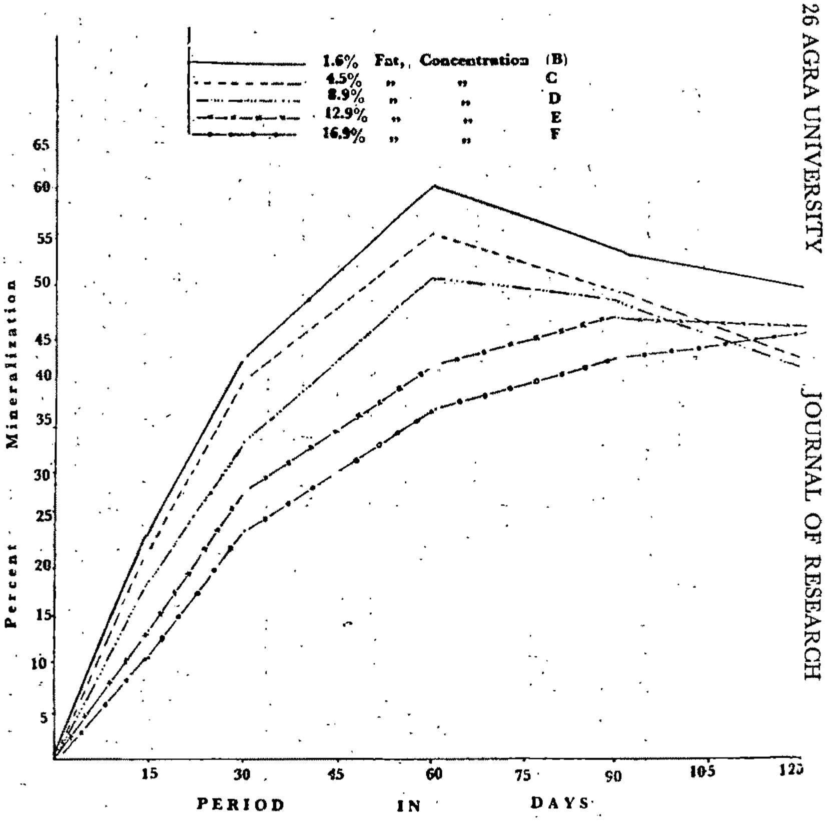

FIG. 2. Neem seed oil-cake.

The materials were added to the soil at the rate of 1% nitrogen.

The fat content of cakes was varied either by extracting the material with the common fat solvents or by adding the corresponding oil to bring the fat content to the desired level. The following table contains the fat concentrations of the different cakes used in this investigation.

Percentage of Fat in Cakes and Wool-Waste

MATERIAL	*PERCENTAGE OF FAT*
1. Castor Cake	1.2
2. ,, ,,	3.5
3. ,, ,,	7.0*
4. ,, ,,	10.5
5. ,, ,,	14.0
1. Neem Cake	1.6
2. ,, ,,	4.5
3. ,, ,,	8.9*
4. ,, ,,	12.9
5. ,, ,,	16.9
1. Mahua Cake	1.4
2. ,, ,,	3.6
3. ,, ,,	5.7 (Water extracted)
4. ,, ,,	6.8*
1. Wool Waste (in Pots)	1.7
2. ,, ,,	3.2
3. ,, ,,	7.1*
1. Wool-Waste (in flasks)	1.7
2. ,, ,,	7.1

The soil was sieved through a 2 mm sieve. The cakes were also ground to pass through a 2 mm sieve in order that they may mix well with the soil, while the wool-waste was cut into small bits.

The moisture contents of pots were maintained at 12-16% by frequent watering and for analysis representative samples were taken. The following determinations were made periodically:—

NH_3—N, No_3—N, and Total Nitrogen,

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*Fat initially present in the cake.

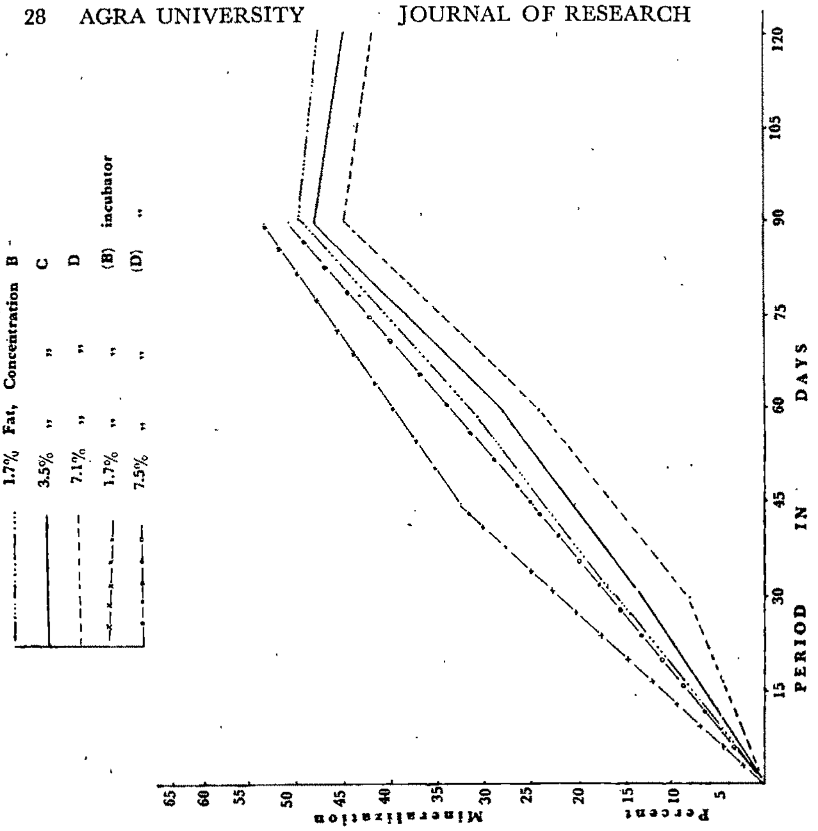

FIG. 4. Wool-waste.

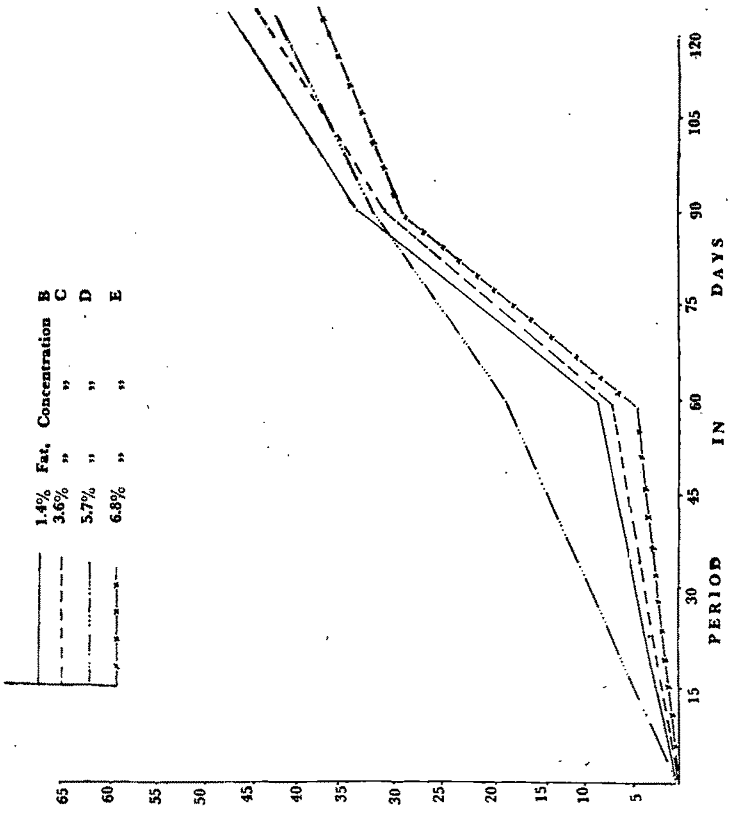

FIG. 3. Mahua seed oil cake.

EXPERIMENTAL RESULTS

An examination of the curves in figs. 1 & 2 for castor and neem cakes respectively, indicates that the mineralization of nitrogen increased with the period of decomposition, till 60 days with concentrations B.C. & D. The drop in mineralization after 60 days with these concentrations suggests some losses possibly due to denitrification. In E & F with a higher percentage of fat the mineralization data suggest that the total availability of nitrogen is not adversely affected by higher fat contents in the cakes except that the process is retarded.

Figure 3 dealing with *mahua* cake indicates that there is no significant nitrification till 60 days. After 60 days the nitrification starts with a tendency to increase till 120 days. Cake applied in concentration D which was extracted with water shows highest percentage of mineralization at 60 days. This may be attributed to the removal of mowerine by water extraction. In the rest high mowerine content appears to delay the nitrification.

With wool-waste in fig. 4 the mineralization is greatest at 90 days with all the concentrations in both the pots and the flasks. Mineralization is however greater with the same concentrations in the flasks under controlled conditions at 35°C. This increase is apparently due to the optimum conditions for the micro-organisms in the incubator. Miyake (9) has also recorded a similar observation.

A comparison of curves in figures (1-4) for the total mineralization indicates that the highest mineralization took place in castor cake followed by *neem* cake, wool-waste and *mahua* cake. The reason for greater minerlization in castor cake seems to be due to the easy availability of its protein to the micro-organisms. Low mineralization in neem cake is due to the bitter substance (nimboline) present in its oil and cake while in the case of wool-waste low nitrification in spite of its high nitrogen content may be attributed to the complex nature of its protein.

DISCUSSION

The low concentration of fats brings about greater mineralization than the higher ones. This may be due to immediate decomposition of smaller amount of fat, thereby providing an easy source of available energy for micro-organisms with the resultant multiplication and activity of the hetrotrophic bacteria which liberate nitrogen in an available form.

Low mineralization with higher concentrations of fat may be explained on the basis that the organisms are unable to decompose the nitrogen of organic substance owing to their being coated by fat layers; consequently nitrogen is not readily liberated in the available form. Corbet (3) observed that the decomposition of humic matter was delayed due to the coating of fats around the soil particles.

The nature of organic substances also influences the mineralization to a remarkable degree. In the case of castor cake, there is quicker and more mineralization, possibly due to simple and easy availability of its protein. On the other hand slow and low mineralization in the case of *neem* cake, wool-waste and *mahua* cake can be attributed to the presence of complex and toxic substances.

The percentage of mineralization varies with period of decomposition and with the different fat concentrations. In the case of castor and neem cakes with B,C & D concentrations of fat, mineralization progressively increases upto 60 days, after which there is a decrease in the process. With concentrations E & F, mineralization increases steadily upto 90 and 120 days, though the peak attained here is lower than with the smaller concentrations of fat. This increased availability of nitrogen with low concentration of fat is due to quicker decomposition of fat and easy availability of energy to the micro-organisms. This experiment suggests that castor cake and neem cake with lower concentrations of fat should be applied 15 days before the sowing of crop.

With *mahua* cake however delayed mineralization warrants the application of this cake at least 8 weeks before it is expected to help the crop.

SUMMARY

Castor, *neem*, & *mahua* cakes and wool-wastes were added to the soil with varying amounts of fat in them at fixed percentage of nitrogen in order to study their effect on the mineralization of nitrogen. The percentage of mineralization is greatest in castor cake followed by neem cake, wool-waste and mahua cake being 78%, 61%, 50% and 47% respectively.

Mahua Cake after extraction with hot water gives the highest amount of mineralization at 60 days in comparison to other concentrations. This demonstrates the toxic effect of mowerine on nitrifying organisms.

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EFFECT OF TEMPERATURE ON THE SURVIVAL OF THE RUST OF BAJRA CAUSED BY *PUCCINIA PENNISETI* ZIMM.

By K.C. Basu-Chaudhary, *Botany Department, Agra College, Agra.*

The rust of bajra (*Pennisetum typhoides* Stapf. & Hubb.) caused by *Puccinia penniseti* Zimm. is very common in India. Bajra is sown in Uttar Pradesh with the advent of the monsoon and harvested by late October. The disease appears about the end of September.

The uredo- and teleutospores left over after the harvest are subjected to intense heat (45° C maximum temperature under shade) of the plains during the summer, which is the critical period in the life-cycle of the fungus in India. Teliospores are killed in 36 hours at 45°-50°C (Prasada 1948). Survival of the rust in the uredo stage during the absence of the crop is all the more improbable but there is no precise data on the subject.

A large number of germination tests were conducted to determine the maximum period for which uredospores remain viable irrespective of the percentage germination, germination percentage, germination power and germination period at temperatures ranging from 5°-52°C. The various ranges of temperature used in these experiments were maintained as follows: 5°-15°C in a refrigerator, 17°-24°C in an ice box, 26°-36°C in incubators heated by electric bulbs of different watt powers and 38°-52°C in Hearson's nine chambered incubator. Throughout the experiments a fresh collection of uredospores was taken for each set of temperature. Temperature in the ice box and bulb-heated incubator was recorded with a maximum and minimum thermometer. The results of the effect of temperature on the various aspects of germination and viability are presented in Table I.

Table I. Effect of temperature on the longivity, percentage, period and power of germination of uredospores of *Puccinia penniseti* Zimm.

Temperature °C	Longivity in days.	Percentage germination after 24 hours.	Germination period in hours.	Germination power (length of germ tube in μ after 6 hours.)
5—6		NO GERMINATION		
8—9		4	6.00	30
11—12		5	6.00	45
14—15	150	14	5.50	45
17—18	*	19	5.30	60

*Observation not taken as it was not possible to maintain working of the ice box for a very long time evidently due to high recurring expenditure.

Temperature C°	Longivity in days.	Percentage germination after 24 hours.	Germination period in hours.	Germination power (length of germ tube in μ after 6 hours.)
		NO GERMINATION		
20—21	40	23	4.40	60
23—24	36	35	4.20	90
26—27	30	44	4.15	120
29—30	26	58	4.00	150
32—33	18	70	4.00	165
35—36	11	65	4.10	140
38—39	9	59	4.15	125
41—42	8	55	4.20	100
44—45	3	35	4.15	90
47—48	2	20	4.20	80
49—50	12 hours	10 (after 10 hours)	4.40	30
51—52		NO GERMINATION		

The longivity of uredospores seems to be directly related to temperature, the uredospores loosing the capacity to germinate after 12 hours at 49°-50°C while at 14°C the viability lasts for 150 days. Temperature also has a direct effect on the germination percentage. The uredospores fail to germinate at 5°-6°C but as the temperature is raised the germination percentage is accelerated reaching an optimum at about 32°-33°C, but falling again until germination ceases at 51°-52°C. The curve for percentage germination almost coincides with that of germination power (the length of the germ tube after 6 hours) showing that the range 32°-33°C is the best for germination of uredospores. The curve for the germination period (time taken for the appearance of the germ tube) also indicates that minimum time is taken for germination at 29°-33°C. Thus it appears that the temperature range 29°-33°C is optimum for germination and viability of uredospores of *Puccinia penniseti* Zimm.

The temperature of Agra during the months of May and June is recorded as 40°-41° C average for the lasts 50 years and reaching 45.8°C (114.5°F vide Metereological records) on certain days. This high temperature during May and June is hardly suitable for the survival of the uredospores since they loose their viability after a week at the most as shown in Table I. Hence, it is evident that the uredospores cannot possibly survive the critical hot months and infect the crop next season. It is, however, to be seen if cultures of the rust in the uredo stage can be maintained under natural conditions during this period. Experiments in this connection are in progress.

Ramakrishnan and Soumini (1948) and Dalela in this laboratory have obtained the aecidial stage of the rust on *Solanum melongena* Linn. by artificial inoculations with germinating teliospores, but it has to be seen if the rust in the aecidial stage survives the critical hot months in Northern India.

SUMMARY

Fresh collections of uredospores were stored at and exposed to different temperatures ranging from 5°-52°C. Their period of longivity germination percentage, germination period and germination power were observed. The role of uredospores in the survival of the rust is discussed.

ACKNOWLEDGMENTS

Thanks are due to Prof. S. Sinha of Agra College for guidance and critical suggestions. I am indebted to the Scientific Research Committee of Uttar Pradesh Government for financial help and also to the Director, Regional Metereological Centre, New Delhi, for supplying temperature data.

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ON SOME INTERNAL ORGANS OF TWO TUBULIFEROUS THYSANOPTERA

By T.N. ANANTHAKRISHNAN, B.Sc. (Hons.), F.Z.S., F.R.E.S., *Lecturer in Zoology, Loyola College, Madras.*

The present paper is an attempt to study some of the internal organs of two Tubiliferous Thysanoptera, *Arrhenothrips ramakrishnae* Hood, the mimusops gall thrips, confined to India and *Cercothrips tibialis* (Bagnall), a large form commonly feeding on *Ficus*, and fairly wide in its distribution. No considerable work has yet been done on the internal morphology of Indian Tubilifera, even though comprehensive work on the anatomy and histology has been done in a few forms by Jordan (1888) on *Phloeothrips brunnea*, Uzel (1895) on *Trichothrips copiosa* and Sharga (1933) on *Haplothrips distinguedens*. On the other hand, the internal morphology of more than fourteen species of Terebrantia has been worked out, the most prominent work being that of Sharga (1933), who has dealt with nine species. I have attempted a study of the alimentary canal, their associated glands and the reproductive systems of *Arrhenothrips* and *Cercothrips*.

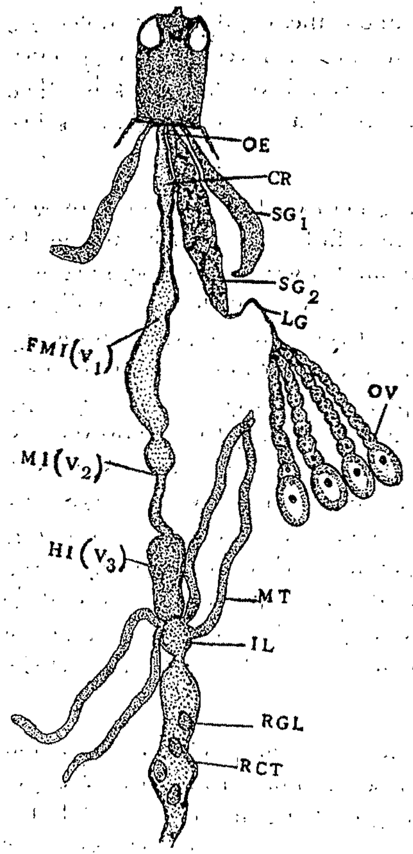

FIG. 1. *Arrhenothrips.* Alimentary canal and ovary.

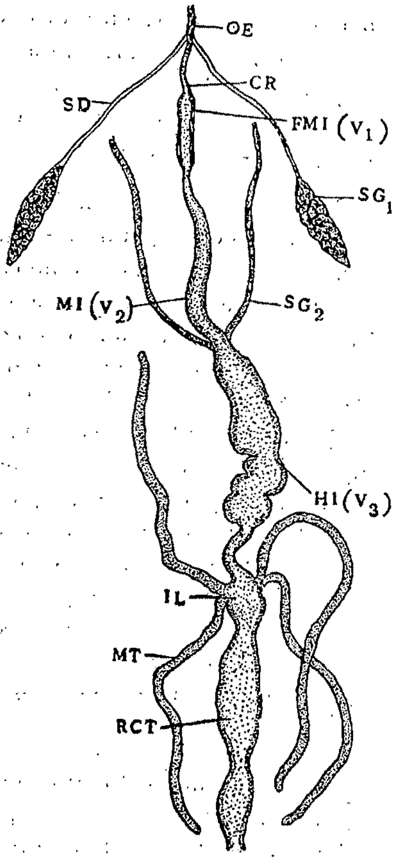

FIG. 2. *Cercothrips.* Alimentary Canal.

Specimens killed with chloroform were tried but did not give satisfactory results. The usual medium of dissecting them alive in 0. 75 percent salt solution with a pair of fine needles under a Leitz binocular microscope proved successful.

I wish to express my sincere gratitude to Prof. R.V. Seshaiyya of the Annamalai University for having given valuable advice and necessary facilities and my thanks are also due to Dr. U. S. Sharga of the Agricultural College, Kanpur for having gone through the paper and offered useful criticisms and advice.

Digestive System

In *Arrhonothrips* (Phloeothripidae, subfamily Liothripinae), the alimentary canal is straight, uncoiled and is just about the length of the insect (2.5 to 2.7 mm). The fore intestine, compared to the other regions is very short, measuring 0.56 mm in length and is about one seventh the total length. The narrow oesophagus, which is 14.5 μ wide at base, leads into a slight crop-like dilatation 22.8 μ wide.

As has been noticed in all the other genera of Thysanoptera, the mid intestine is the longest and occupies about three-fifths the total length of the alimentary canal. The commencement of the mid intestine is clearly seen as a constriction at the base of the crop which first narrows and then gradually enlarges to form the front part of the mid intestine. Instead of using the terminology of Sharga (1933) for the three distinct divisions of the mid intestine, the terminology of Snodgrass (1935) used for the Homoptera as *ventriculus one*, *two* and *three* (Fig. 1 and 2 - V_1, V_2 V_3) has been adopted here. Imms (1925) however uses the terms, 'chambers of mid intestine' for the Homoptera. The first ventriculus is the longest part of the midgut, narrow at base and widening below and measuring 87 μ wide at base. The second ventriculus is differentiated from the first by a constriction leading into a globular basal region and a distal tubular region and measures 0.14 mms in length. The widths of the basal globular region and the narrow distal region are 65 and 29 μ respectively. The third ventriculus is distinguished by its dark brown colour and is almost rectangular measuring 0.148 mms long and 0.102 mms wide.

Situated at the junction of the mid and hind intestines are four malpighian tubules (Mt) the number of which seem to be constant for all known forms. The hind intestine is just half the length of the mid intestine. Buffa's (1898) division of the hind gut into pre-glandular, glandular and post glandular regions, does not seem to be a definitive demarcation and Sharga (1933) has confirmed this as "the division does not lie sufficiently on a homologous structural basis." Hence Buffa's division is one of convenience and the demarcation of the hind intestine into the ileum and the rectum based on the definitely observed constriction between the two, has been rather uniform as has been observed in both *Arrhenothrips* and *Cercothrips*. *Arrhenothrips* shows clearly four rectal glands (RGL) which are well separated. Since the position of the rectal glands is a variable feature (i.e. either aggregated anteriorly or posteriorly or well separated) the division of the rectum into glandular and postglandular regions, also becomes inconcievable and this is confirmed by the fact that no prominent rectal glands could be seen in *Cercothrips*. The ileum (IL) in *Arrhenothrips* is 65 μ wide and the rectum (RCT) is much wider consisting of a basal region which dilates before opening out.

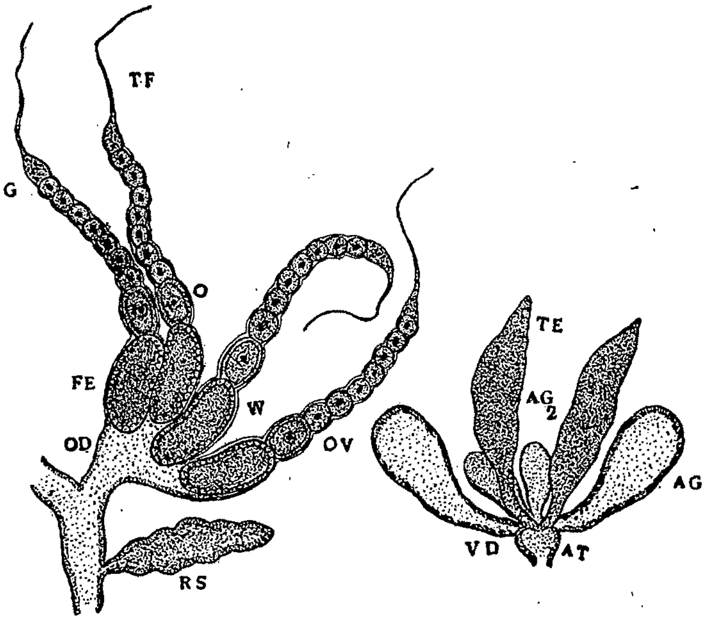

FIG. 3. *Arrhenothrips*. Ovary on the left and male reproductive organs on the right.

In *Cercothrips* the alimentary canal, especially the mid intestine is much wider than *Arrhenothrips*. The oesophagus is long and narrow, very slightly widening distally so that a crop hardly exists. The mid gut occupies two-thirds the length of the alimentary canal. The first ventriculus is an almost uniformly wide cylindrical tube, narrowing at its posterior extremity to end in the second ventriculus which subsequently widens. The demarcation of the second and third ventriculus is distinct since the second ventriculus suddenly dilates to form a wide sac, which becomes further sacculated at its distal end. This sac subsequently narrows into a small tube opening into the hind gut. The width of the saccular part is 145 μ. The hind gut consists of a small ampulla-like *ileum* leading into a wide rectum, narrowing at first and subsequently widens out. Rectal glands are not at all clear.

SALIVARY GLANDS

Both *Arrhenothrips* and *Cercothrips* clearly have two pairs of salivary glands. Of these one is definitely longer (SG_1) and the other shorter (SG_1). In *Arrhenothrips* the longer pair is connected to the terminal filament of the ovary by a ligament (LG). On the other hand the long pair in *Cercothrips* is narrow, long and tubular and takes its origin from the hind end of the second ventriculus. A clear lumen is seen in the longer pair in *Arrhenothrips*. The short pair of salivary glands in *Arrhenothrips* is connected by a short thin duct. But in *Cercothrips* they hang lower down and are connected by long and thin salivary ducts. The longer pair of salivary glands in *Arrhenothrips* measure 0.51 mm long and 116 μ wide. The shorter pair measures 0.43 mm long and 58 μ wide. In *Cercothrips* they are only 0.154 mms long.

MALPIGHIAN TUBULES

The four malpighian tubules are dark brown structures two of which are directed forwards and the other two backwards. They are much longer in *Cercothrips* being 0.79 mms long and 29 μ wide.

REPRODUCTIVE SYSTEM

Female.—In *Arrhenothrips* the ovary (Fig. 3a) is composed of eight ovarioles (OV), four on each side. The terminal filaments (TF) of all the ovarioles unite to form a single thread, which is attached to the long pair of salivary glands. In each ovariole nine oocytes (0) are found, of which the ones at the base are longer. The most proximal oocyte in the well developed ovary assumes the characteristic bean-shaped appearance of the egg. Sharga (1933) remarks that "in no case has it been observed that two oocytes of the same ovarian tube, may reach simultaneous maturity." It has been clearly seen in *Cercothrips* where in each well developed ovarian filament, four equally well developed eggs (length 0.45 mms × width 0.145 mms) lie one above the other. One peculiarity is seen that the concave side of the egg alternates in adjacent eggs *i.e.* in one egg if the concave side is to the left, in the next, it is to the right and so on. (Fig. 4 a) In one instance on teasing the ovary two first larval instar forms were observed, which I believe, is a clear case of ovoviviparity.

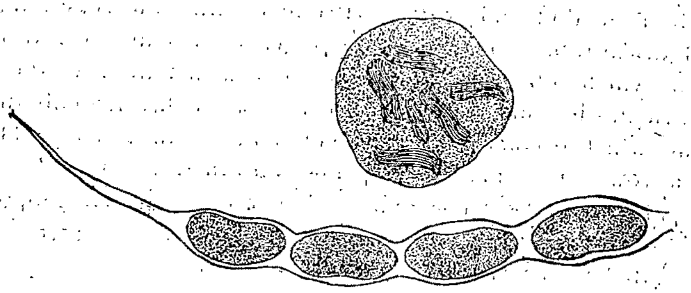

FIG. 4. *Cercothrips.* Spermatozoa above and a single ovariole below.

The vitellarium, germarium and terminal filament are clear in *Arrhenothrips*, the ovary being of the panoistic type, with a small germarium showing numerous cells and no vitellogenous cells. Each ovariole has nine oocytes in a chain. The oviducts (OD) are short and broad and associated with the common oviducal chamber is an elongated lobed *receptaculum seminis* (RS) measuring 0.58 mms long and 0.132 mms broad.

Male.—In *Arrhenothrips* the testes (Fig 3b TE) are elongate, narrow at base and wide at middle measuring 0.261 mms long and 58 µ broad. The basal part narrows to form the vas deferens (VD), which opens into the atrium (AT). Acetocarmine squash of the testes revealed highly elongated and curved spermatozoa (Fig. 4b). Younger testes squashes revealed spermatogonia and spermatids. Two pairs of *accessory glands*' a large bladder-like outer pair (AG_1) and a smaller inner pair (AG_2) opening into the atrium are clearly visible.

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*Not seen in original.

THE EXTERNAL MORPHOLOGY AND SKELETON OF *MYLABRIS PUSTULATA* (THUMB.) (MELOIDAE: COLEOPTERA)*

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Though the skeletal system of beetles has been studied by several workers, meloid beetles seem to have been rather neglected. Blood's description (2) of the external features of *Pyrota mylabrina* does not include all the sutures and regions. In this paper I have given a detailed description of the skeletal system of *Mylabris pustulata*. The gnathal appendages are excluded from here and will be dealt with in the organs of alimentation.

External Features

The adult is a medium-sized, elongate black coloured beetle, conspicuously banded bright to dark red. The colouration is that known as "warning". The size and the bands of the colour are extremely variable. Adults measure from 15-35 mm in length. The pubescence is denser on the venter than on the dorsum. There are no setae on the dorsal median and ventral median regions of metathorax.

The body (Figs. 1,2,3) is divided by constrictions into three parts. The first division is the head which is movably joined through a membranous neck or cervix (Fig.3 *cvx.*) to the second division of the body viz. the compact thorax. The third division is the elongate abdomen which is attached to the broad rear end of the thorax anteriorly and tapers posteriorly. In a fully grown beetle measuring 35 mm the head is 5 mm long. It is as wide across the eyes as long. The prothorax (Figs. 1,3, lT) is nearly as long and wide as the head but it is somewhat narrower anteriorly than posteriorly. Mesothorax (Fig. 3,2*th*) and metathorax (3*th*) are 8 mm long but slightly less wide. Abdomen is the longest region and measures 17 mm in length. It is widest in the middle but the width reduces posteriorly. The male has a median notch in the last abdominal sternite while in female it is entire.

The head is a broadly oval shiny, hard, rigid capsule heavily pigmented and sculptured with irregularly scattered pits or punctae. The entire dorsal surface is covered with setae except the eyes and the dorsal median line on the frons which probably represents the coronal suture and is broad anteriorly than posteriorly. The head bears a pair of moderately long eleven segmented freely movable sensory appendages the antennae (Fig. 2, *ant*). The two antennae are inserted fairly apart anteriorly on the head just above the *epistomal*

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suture (Fig. 5 A, C *epsn*) close to the orbital border. Each antenna is inserted in *antennal socket* (*ants*) provided with a distinct *antennal sclerite* (*as*) with which it is movably articulated by a membrane which gives the antenna greater freedom of movement. Like most of the beetles they are eleven segmented and uniformly covered with setae. The first segment is the *scape* (Fig. 2, *scp*), the second *pedical* (*ped*) and the remaining eight segments constitute the *flagellum* or *clavola* which consists of two oval (*o*) four serrately produced *funicular* (*fun*) and three flat club segments (*clv*).

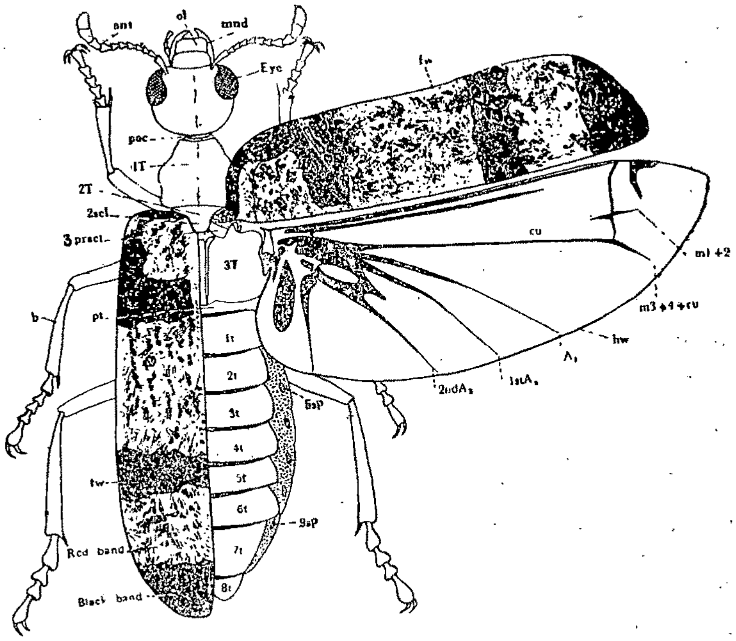


FIG. 1. Dorsal view of male with right elytra and wing opened *b*. leg; *clp*. clypeus; *fm*. femur; *fw*. elytra; *hw*. hindwing; *mnd*. mandible; *o*. occiput; *ol*. labrum; *poc*. postocciput; *pt*. postnotum; *ta*. tarsus; *tb*. tibia; *tsp*. tibial spur; 2*scl*. scutellum of mesothorax; 5.9 *sp*. fifth and ninth spiracles respectively; 1-8*t*. first to eighth abdominal terga; 1.2.3*T*. pro, meso and meta notum respectively.

The scape is the largest segment. It has a narrow stalk and a broad distal end. The pedicel is ball like. First seven segments of the flagellum or third to tenth segments of the antenna are quadrilateral in shape with narrow proximal and broad distal ends. The narrow ends are devoid of setae. Each segment is broader than the preceding segment. Each segment is joined with the other by a narrow intervening membrane which allows very little movement of the segments. The scape is attached to the socket by a pivot-like process of the antennal sclerite, the *antennifer* (Fig. 5,A,C,*antf*) on the outer side *i.e.* morphologically the ventral side of the generalized insect head so that the downward migration of the antennae have not involved any appreciable rotation of the antennal socket.

The paired compound *eyes* are large somewhat, reniform, shiny black, widely separated and bulge at the sides of the head and extend even ventrally.

The margin of the eye shows a regular boundary except an inflection at its anterior mesial border near the antennal socket. There is an *ocular diaphragm* situated a little below the level of the general head wall and forms a sclerotzed rim.

There are no ocelli. The mouth is at the anterior end and is surrounded by the gnathal appendages. The *head* is abruptly and rather strongly constricted behind the eyes to form a narrow collar-like posterior part (Figs. 1,3,5 ACD. *oc*). It is movably articulated to the trunk by means of a membranous *neck* (Figs. 1,3,7 *cvx*). This enables retraction of the posterior margin of the head into the anterrior part of the prothorax, as well as free rotation of the head as a whole in various directions while feeding on flowers.

The *thorax* is the great locomotor centre of the body both on the ground and in air. It is composed of three segments viz. a large and fully exposed *prothorax* (Fig. 3 1*th*) a small and inconspicuous *mesothorax* (2*th*) largely concealed under the posterior margin of the prothorax and visible only as a small subtriangular *scutellum* (2*scl*) in the mid dorsal line and large *metathorax* (3*th*) also concealed beneath the wings.

Each of these segments bears a pair of legs (*b*), which are fitted for walking and clinging to branches. The mesothorax and metathorax bear each a pair of wings dorsally. The mesothoracic or the first pair of wings are modified into hard, semi-horny, elongate *elytra* (Fig. 1 *fw*), which are merely stretched out and function as planes to support the body when in flight. When at rest, the elytra are folded back over the dorsum and cover the hind wings (*hw*), metathorax and abdomen nearly completely. They thus serve as protective covers for the delicate and membranous hind wings. The characteristic colour markings of the beetle are really due to the transverse banding of the elytra. When closed over the dorsum, the elytra are wider than the prothorax. The hind wings, which are the true organs of flight, are brown, transparent membranous, reinforced and kept stretched by a definite system of veins (Fig.10A). When not in use, they are folded and tucked in neatly and completely under the protecting elytra.

The *abdomen* is normally concealed from view by the elytra. It is slightly longer than the head and thorax combined and somewhat flattened above. It is composed of nine segments, but some of these are greatly shortened, modified or telescoped under others, so that only eight plates are visible above and six below. The abdomen is capable of considerable distention and can also be extended to great deal. Nine pairs of slit-like apertures called *stigmata* or *spiracles* (Fig. 3. *lsp*-9*sp*) lie in the membranous areas of the segments. The first pair (lsp) lies in between the prothorax and mesothorax and is concealed beneath a large hood-like pronotum. The second spiracle (2sp) is in the membrane below the base of hind wings. The first abdominal spiracle (3sp) is the largest and lies in the membrane behind the base of hind wings and laterally below the first tergite. The second to seventh abdominal segments have each a pair of spiracles (4sp-9sp) in the membranous sides of segments. The eighth segment does not bear spiracle in this beetle. On the other hand in all the species of beetles studied by Tanner (17) a spiracle has been shown in the eighth segment. The anal and genital openings are at its posterior end. On either side of the anal opening lie the paired *paraprocts* (Fig. 5 *papt*). The *genital opening* occurs below the *anus*. The female has also a pair of coxopodites modified into *second valvifer* (Fig. 3 *vlfr*) on the eighth segment. Its appendage is third valvula. (val).

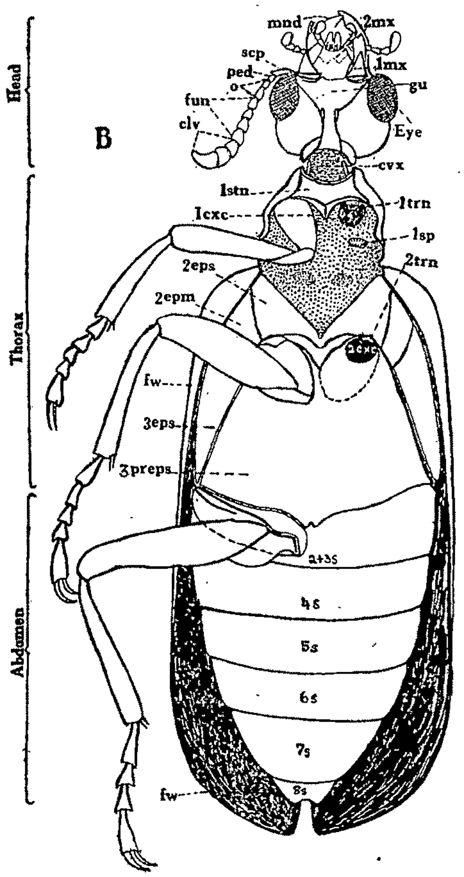


FIG. 2. Ventral view of male with elytra and wings folded. Legs of left side removed to show the coxal cavities. *ant.* antenna; *b.* leg; *clv.* club segments; *cvx.* neck; *fun.* funicular segments; *fw.* elytra; *gu.* gula; *mnd.* mandible; *o.* oval segment; *Scp.* scape; 1.2 *cxc.* coxal cavities of fore and midlegs respectively; 2 *epm.* mesepimeron; 2*eps.* mesepisternum; 3*eps.* metepisternum; *lmx.* maxilla; 2mx. labium; 3*preps.* preepisternum of metathorax; 3 *prsct.* prescutum of metathorax; 2 + 3*s* fused second and third abdominal sterna; 4*s* –9*s*. fourth to eighth abdominal sterna; 1*stn.* prosternum; 1*sp.* first spiracle; 1.2 *trn.* trochantins of fore and mid-legs respectively.

HEAD

The head of beetles have been described by several workers. Stickney (16) and Snodgrass (14) have described the heads of several species. Blood's

(2) description of the head of *Pyrota mylabrina* is very brief and does not include all the sutures and regions. He has also wrongly labelled certain regions such as the postgen. Internal structures have not been described by any of the above workers in the Meloidae.

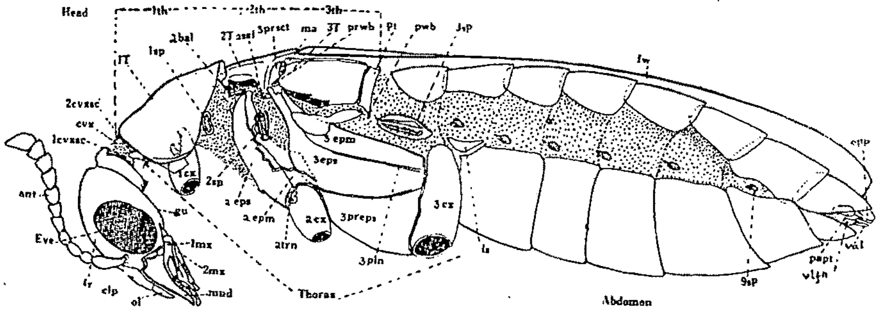


FIG. 3. Lateral view of female. Elytra, hind wing along with axillary sclerites and legs except coxa removed. *ant.* antenna; *clp.* clypeus; *cvx.* neck; *fw.* elytra; *epp.* epiproct; *fr.* frons; *gu.* gula; *ls.* laterosternite; *ma.* membranous area; *mnd.* mandible; *ol.* labrum; *papt.* paraproct; *prwb.* prealer bridge; *pt.* postnotum; *pwb.* postalar bridge; *val.* third valvula; Vfr. second valvifer; ; 2 *bul.* basalare of mesothorax; 1.2 *cvxsc.* first and second cervical sclerites respectively; 1.2.3 *cx.* coxae of fore, mid, and hind legs respectively; 2 *epm.* mesepimeron; 3 *epm.* meteprimeron; 2 *eps.* mesepisternum; 3 *eps.* metepisternum; 1 *mx.* maxilla; 2 *mx.* labium; 3 *plm.* pleural suture of metathorax; 3 *preps.* prepisternum of metathorax; 3 *prsct.* prescutum of metathorax; 2 *sal.* subalare of mesothorax; 1.2 *sp.* first and second thoracic spiracles respectively; 3.9 sp. first and seventh abdominal spiracles respectively; 1.2.3.*T.* pro, meso and metanotum respectively; 1.2.3 *th.* pro, meso and metathorax respectively; 2*trn.* trochantin of midleg.

The *head* (Fig.5) forms a continuously sclerotized, strong, rigid, and heavily pigmented capsule, without visible lines of the fusion of the component segments. In the following description of the head of *Mylabris* the sutures and cranial areas have been described according to Hansen's view. (109)

The *head* (Fig. 3) is prognathous as the mouth parts are directed forwards. It is also *hypognathous* as the beetle usually retracts the head so that the mouthparts come to lie below. The posterior surface of the head is occupied by the opening from the head into the neck. It is a large aperture called *foramen magnum* or *occipital foramen* (Fig. 5 B. *for*).

Sutures of the Cranium.—In the adult, the majority of the cranial sutures are obsolete or surpressed, the boundaries of different regions are for the most part obscure and the areas can not be definitely defined, but only as general regions. The sutures generally mark the presence of endoskeletal ridges of cuticula. Such chitinous submarginal ridges encircle the eyes, antennal socket and occipital foramen. Besides strengthening they provide for the attachment of muscles.

The dorsal surface of the head forms a *vertex* (Fig.5). A frontoclypeal area is separated by an *epistomal* or *frontoclypeal suture* (*epsn*) into a *clypeus* (*clp*) in front and a frons (*fr*) behind. The epistomal suture forms a strong ridge on the innersurface called the *epistomal ridge* (*epsr*). Snodgrass (15) states "It is clearly a secondary device for strengthening the head wall and may be suspected of having been independently developed in some cases." Ferris (7) states "It represents the segmental lines between the antennal and the preantennal segments." The clypeus (*clp*) is a sclerotized membrane which articulates it with the labrum. There is no anteclypeus. Dorsally the clypeus shows a little curvature which evidently gives more surface to the lower chamber of the buccal cavity.

The frons represents an area of the head above the clypeus and between the eyes. It is not demarcated from vertex by any sutural line. One area merges into another. There is an obscure longitudinal line on the frons. It is named *coronal suture* (Fig. 5A. *corn*). It is broad and more prominent anteriorly than posteriorly. It is distinguished from other lines of the head in that it does not form internally a ridge. A suture of similar nature has been described by Khatib (11) in *Galerucella*. According to Snodgrass (15) this suture is the line along which the head cuticle of the immature insect splits at ecdysis and hence suggests the name *ecdysial line* or *suture*. DuPorte (6) says "the ecdysial suture is a narrow line along which the sclerite and usually pigmented exocuticle is not developed." Blood (2) has not described any such structures in the meloid *Pyrota mylabrina* described by him.

The frons is extended behind and below the eyes to form *gena* (Fig. 5 B,C. *ge*)

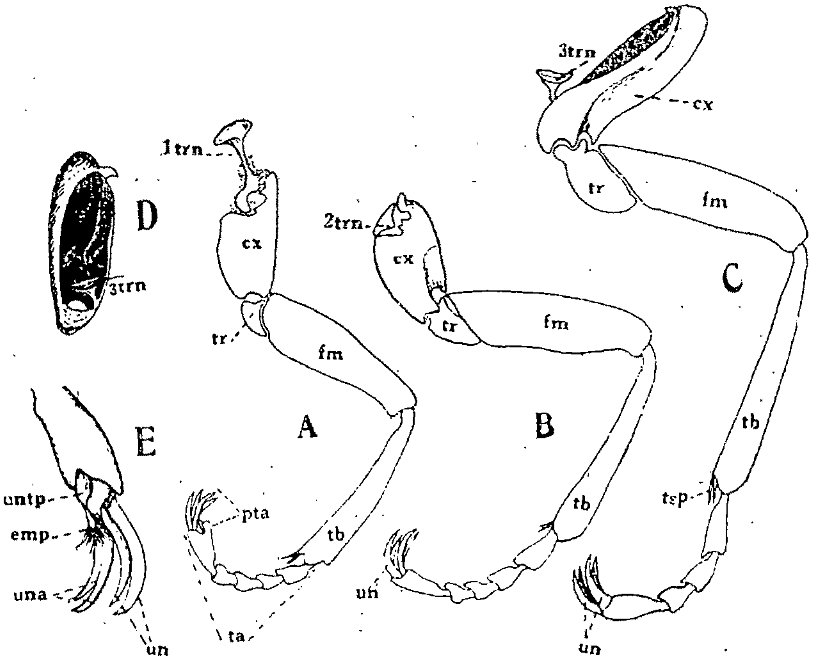


Fig. 4. A, B, C. fore, mid, and hindlegs respectively *cx.* coxa; *fm.* femur; *pta.* pretarsus; *ta.* tarsus; *tb.* tibia; *tr.* trochanter; *tsp.* tibial spur; *un.* claws; 1.2.3. *trn.* trochantins of fore; mid and hind legs. D. Inner view of the hind coxa ; 3 *trn.* trochantin of hind leg. E. Lateral view of the distal segments of tarsus and pretarsus, *emp.* empodium; *un.* claws; *una.* appendage of claw; *untp.* unguitractor plate.

and *subgena* (*sge*). The genae occupy large areas ventrolaterally. Posteriorly their boundaries are marked by the *occupital suture* and mesially by *gular* (*gu*) and *subgenal suture* (*sgen*). The subgenae are narrow areas on either side of the mandibular articulations which strengthen the cranial walls along the lines of attachment of the gnathal appendages. These areas are set off by the subgenal sutures which run from the *posterior tentorial pits* (*tntp*) to the outer ends of the epistomal suture. The part of the subgena occupied by the mandibles is called as *pleurostoma* and the area behind it lodging the maxilla as the hypostoma. Accordingly the subgenal suture is also divided into the *pleurostomal* and *hypostomal sutures* marking the respective boundaries. According to Ferris (7) the subgenal area is in part merely a secondary sclerotization of the conjunctival membrane between the mandible and the cranium. He suggests that this structure should be eliminated from the generalized head. He also mentions that the terms "pleurostoma", "hypostoma" and "subgenae" as applied to portions of a supposed sclerite forming the ventral region of the cranium have no meaning. The term hypostoma may in some cases refer to what is perhaps a vestige of the maxillary segment. The subgenal suture has no existence, according to him. But in the light of the head of the beetle here described these areas are well marked and whatever be their homologies, have to be accepted and named as such according to the terminology of Snodgrass (14).

An *occipital suture* (*ocn*) runs behind the vertex and genae and demarcates the *occipital arch* (*oca*) which is bounded posteriorly by the post*occipital suture* (*pocn*). The occipital arch is ring-shaped sclerite which comes to lie between the occipital and postoccipital sutures. Its dorsal part is called the *occiput* (*oc*), its lateral parts lying posterior to the genae are called *postgenae* (*pge*). Blood (2) has not described this in the description of *Pyrota mylabrina* and has wrongly labelled the subgenae as postgenae.

The occiput is very distinct in all Coleoptera. In members of the families Staphylinidae, Carabidae and Silphidae the occiput is not as wide as in *Mylabris*, but is constricted and extended backwards so as to form a complete neck. Bostick (3) has not described this structure in the head of carabid *Calosoma scrutator*.

The *postocciput* (*poc*) is the narrow posterior ring of the cranium which is set off from the occipital arch by the postoccipital suture (*pocn*). It gives attachment to the neck membrane. The postocciput surrounds the foramen magnum (*for*) behind, through which passes the alimentary canal, the longitudinal tracheal trunk and the nervous system. Its outer border is inflected into the head cavity to form an internal ridge called the *postoccipital ridge* (*pocr*) for the attachment of the muscles of the neck region. The ridge bears on either side a condyle for the articulation of the cervical sclerites. According to Snodgrass (14) the postocciput probably is a sclerotic remnant of the labial segment. According to Ferris (7) it represents the dorsal portion of the maxillary segment and the postoccipital suture represents the line between the mandibular and maxillary segments. The postoccipital suture not only surrounds the foromen magnum

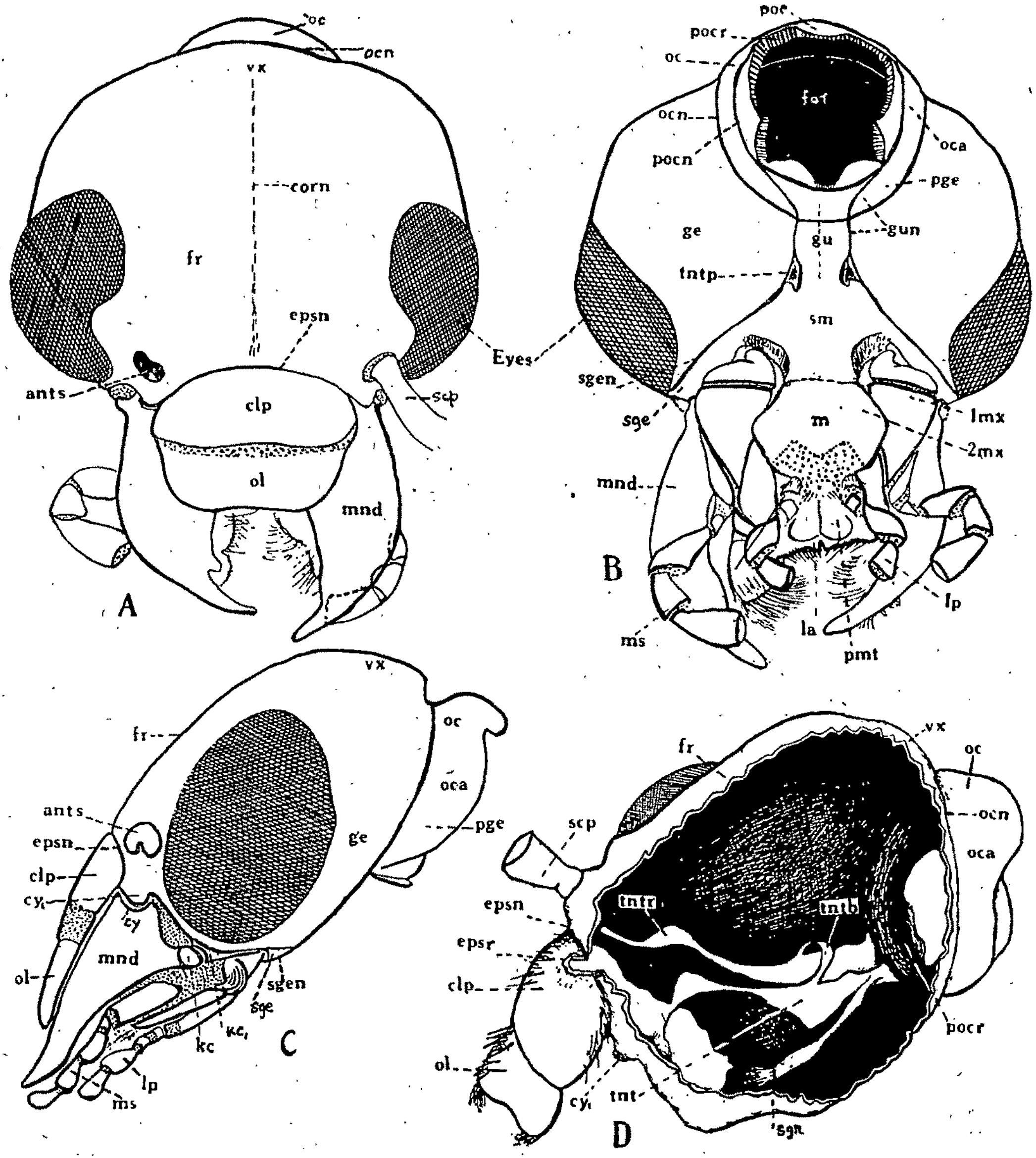
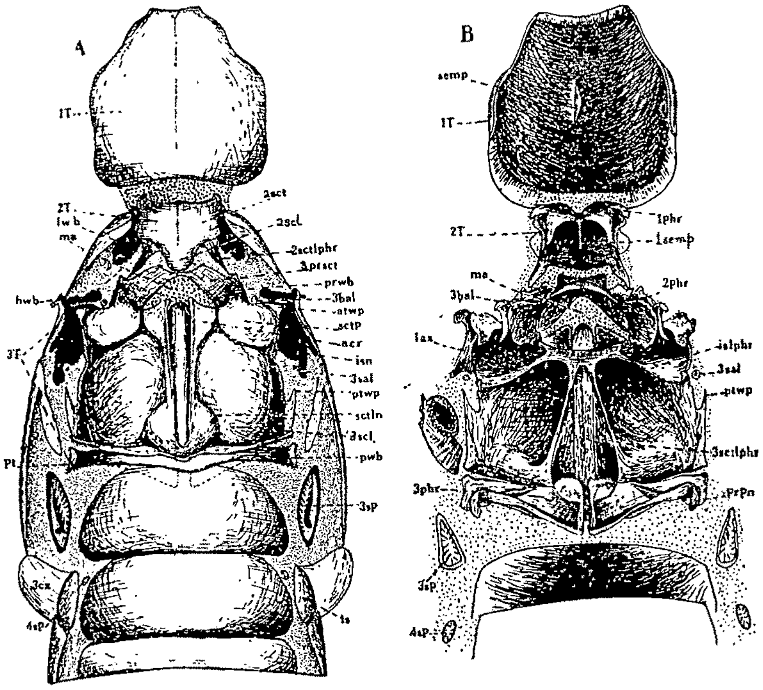


FIG. 5. Skeleton of the head. A. Dorsal view B. Ventral view. C. Lateral view. D. Head cut open to show the tentorium in dorsolateral view *ants.* antennal socket; *antf.* antennifer; *clp.* clypeus; *corn.* coronal suture; *cy.* anterior concavity of the mandible; *cy.* anterior articulation of the mandible *epsn.* epistomal suture; *epsr.* epistomal ridge; *for.* foramen magnum; *fr.* frons; *ge.* gena; *gu.* gula; *kc.* posterior condyle of the mandible; *kc.* posterior articulation of the mandible; *la.* ligula; *lp.* labial palp; *m.* mentum; *mnd.* mandible; *ms.* maxillary palp; *oc.* occiput; *oca.* occipital arch; *ocn.* occipital suture; *ol.* labrum; *pge.* post gena; *poc.* post occiput; *pocn.* post occipital suture; *pocr.* post occipital ridge; *scp.* scape; *sge.* subgena; *sgen.* subgenal suture; *sgr.* subgenal ridge; *sm.* submentum; *tnt.* tentorium; *tntb.* tentorial bridge; *tntp.* posterior tentorial pits; *tntr.* sclerotized arms of the tentorium; *vx.* vertex.

but extends ventrally upto the posterior tentorial pits. The area below the foramen magnum remains membranous in the grasshopper and cockroach, but in the beetle this region is sclerotized to form a *gula* (Fig. 5B. *gu*), separated by two *gular sutures* (*gun*) on either sides. These are ventral parts of the postoccipital suture running between the base of the postocciput and the posterior tentorial pits. The formation of the gular sclerite is associated with the prognathous condition of the head and is characteristic of the order Coleoptera. The head is turned upwards on the neck causing the true anterior surface to become dorsal and the mouth parts to be directed forward. The true or morphological posterior surface becomes ventral. Campau (4) says that in *Chauliognathous* the gular region has become reduced to median line only. Snodgrass (14) interprets the gula of coleopterous larvae e.g. *Silpha* as a development of the ventral margin of the foramen magnum.

Inflections of the cranial wall into the cranial cavity constitute the



Fɪɢ. 6. Skeleton of the thorax. A. Dorsal part outer aspect. B. Dorsal part inner aspect. *acr.* alacrista; *atwp.* anterior notal wing process; *fwb.* fore wing base; *hwb.* hind wing base; *islphr.* intrascutellar phragma; *isn.* intrascutal suture; *ls.* laterosternite; *ma.* membranous area; *propn.* downwardly directed process of postnotum; *prwb.* prealar bridge; *pt.* postnotum; *ptwp.* posterior notal wing process; *pwb.* postalar bridge; *sctln.* scuto-scutellar suture; *sctp.* scutellum proper; *semp.* endoskeletal plate; 1 *ax.* first axillary sclerite of metathorax; 3 *bal.* basalare of metathorax; 3 *cx.* coxa of the hind leg; 1 *phr.* phragma of mesothorax; 2.3 *phr.* anterior and posterior phragma of metathorax; 3 *prsct.* prescutum of metathorax; 1 *semp.* small median plate 3; *sal.* subalare of metathorax 2.3 *scl.* scutellum of meso and metathorax respectively; 2 *sct.* scutum of mesothorax 2.3 *sclphr.* scuto-scutellar phragma of metathorax; 3.4 *sp.* first and second abdominal spiracles respectively; 1.2.3 *t.* pro, meso and metanotum respectively.

tentorium (Fig. 5D. *tnt*) or the endoskeleton of the head. The tentorium reinforces the cephalic capsule and provides attachment to various cephalic muscles and also supports the brain and pharynx. The tentorium in *Mylabris* is greatly reduced and much less extensive than in grasshopper. The anterior tentorial pits are obliterated but the *posterior tentorial pits* are visible (*tntp*) at the ends of *gular sutures* (*gun*). The posterior tentorial pits according to Ferris (7) are situated between the maxillary and mandibular segments or is an invagination from the maxillary segment itself. The same pits have also been named as gular pits by Blood (2) in his description of *Pyrota*. The tentorium of *Mylabris* comprises of two *sclerotized arms* (*tntr*) extending forward and upward from the ventral surface of the postoccipital inflection dorsally to the cranial wall above the bases of the mandibles. As they extend diagonally upward and forward they become slender and thinner in the middle and again become flattened and broader till they terminate. The two arms are connected together by a cross bar or *tentorial bridge* (*tntb*). Such a tentorium has not been described in any of the beetles. The tentorium of *Chauliognathous* is much reduced and the posterior tentorial arms are not connected by a tentorial bridge. Blood (2) has not described the tentorium of *Pyrota* while describing its head. There is a very faint ridge, the *subgenal ridge* (*sgr*) internally along the subgenal suture.

This description of the head of *Mylabris pustulata* agrees that of most Coleoptera in the absence of several sutures, orientation of the gnathal appendages, the development of gula, forward migration of posterior tentorial pits and the absence of anterior tentorial pits. These are all signs of specialization and advancement. The only primitive feature seen is the relation of the antennifer with the primitive condition.

THORAX

The *thorax* (Figs. 2,3) as usual is divided into pro, meso and meta thorax. The *prothorax* (Figs. 3 *1th*) is quite separate from the *mesothorax* (*2th*). The meso and metathorax (2th, 3th) are very intimately welded together and are highly specialized to perform the important function of flight.

It is attached to the head by a membranous area called *cervix* or *neck* (*cvx*). It encloses a larger membranous area ventrally. In the middle the ventral membrane shows two oval sclerites (Fig. 2). The anterior end of the neck is articulated with the posterior end of the cranium while its posterior end is articulated with the anterior end of the prothorax. In natural position neck is dorsally completely covered by the overlapping pronotum and is only seen when the head is extended anteriorly. The morphological nature of neck has been explained by Snodgrass (14). He considers it as posterior membranous part of the labial segment and anterior of the prothorax. His conception is based upon the presumption that postocciput represents the dorsal part of the labial segment and only this region can contribute to the formation of the neck. Two pairs of *cervical sclerites* (Fig. 3. *cvxc*) are found in the membranous neck placed diagonally in its ventrolateral region. The first pair of the posteroventral sclerites (*2cvxc*) is an elongated rod. The first pair articulates with the postocciput while the second pair lies free partly retracted into the porothorax. These sclerites give attachment to the muscles which arise from the back of the head and the pronotum. The protracting movements of the head are due to the attachment of these muscles. These sclerites are not found in all the insects. Khatib (11) mentions that there are no cervical sclerites in the neck of *Galerucella*. Blood (2) does not mention any thing about them in his description of *Pyrota*.

Prothorax: The *prothorax* is a single highly sclerotized piece (Figs. 1,3,6, 8. *IT*) containing all the thoracic elements fused together. It is separated from the head and mesothorax by large membranous areas. The entire dorsal surface of the prothorax is occupied by the pronotum (*IT*) which is very large and forms a saddle-shaped sclerite occupying the whole of the dorsum and laterally curving downwards like a collar over the legs. The pronotum is usually large in Coleoptera, some Orthoptera and Hemiptera. The anterior and posterior margins of pronotum are deflected downwards in order to provide attachment to the connecting membrane as well as muscles connecting the head with the

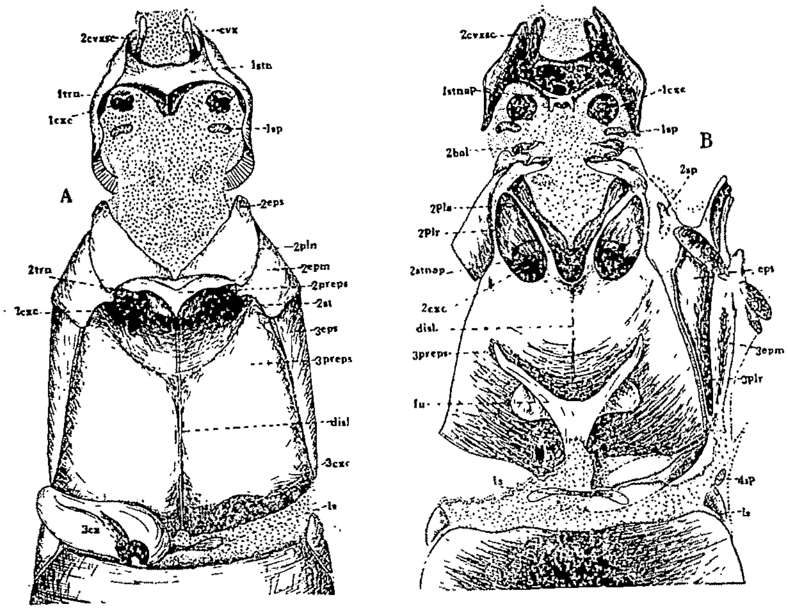


FIG. 7. Ventral part of the skeleton of thorax. A. Outer aspect. B. Inner aspect. *Cvx.* neck *disl.* discriminal line; *fu.* furca; *ls.* laterosternite; 2 *bal.* basalare of mesothorax; 2 *cvxc.* second cervical sclerite; 3 *cx.* hind coxa; 1.2.3 *cxc.* coxal cavities of fore, mid and hind legs respectively; 2 *epm.* mesepimeron; 3 *epm.* metepimeron; 2.3 *eps.* meso and meta episternum; 2 *pls.* pleural apophysis of mesothorax; 2 *pln.* pleural suture of mesothorax; 2.3 *plr.* pleural ridges of meso and metathorax respectively; 2.3 *preps.* preepisternum of meso and metathorax respectively; 1 *s.* first abdominal sternum; 1.2 *sp.* first and second thoracic spiracles respectively; 4 *sp.* second abdominal spiracle; 2 *st.* mesosternum. I*stn.* prosternum; 1.2 *stnap.* pro and mesosternal apophysis; 1.2. *trn.* trochantin of fore and mid legs.

pronotum and of the latter with the mesonotum. The posterior margin of the pronotum similarly extends like a hood over nearly the whole of the *mesonotum* (*2T*). Along the mid-dorsal region is a prominent line in exact apposition to the coronal suture of the head (Fig. 7A). This line is depressed in the middle which is an external mark corresponding to an internal median-longitudinal inflected ridge greatly enlarged into a semicircular *endoskeletal plate* (Fig. 6B. 8 *semp*). The lateral extensions of the pronotum on either side may be termed subnotum, if we follow Khatib's (11) terminology in his work on *Galerucella*. The pronotum does not bear the phragma nor is there a scutellu. Tne *prosternum* (Figs. 2, 9E. *lstn*) is a narrow transverse plate fused with the pronotum. The fusion is so strong that nothing except a dark line is seen which is the only line limiting the boundaries of pronotum and prosterum. The posterior border of the prosternum gives internally a pair of *prosternal apophysis* or the *furcal arms* (Figs. 7B, 8, 9E. *lstnap*). They support the principal longitudinal muscles. The entire ventral plate has been termed sternum. Externally it has a pair of pits which mark the roots of the furcal arms. According to Snodgrass (14) the ventral plate is the eusternum, to which the spinasternum has fused. Due to the presence of the furcal arms, the eusternum becomes divided into a region anterior to the furcal arms and called as *basisternum* and a posterior sclerite bearing the furcal arms as the *sternellum* or *furcasternu*. The division into the above mentioned regions and therefore the sternum, in *Mylabris* is a composite one.

There are no *pleurites* in the prothorax as are commonly found in insects including some beetles. However Bostick (3) describes the presence of pleuron in *Calosoma* where it is divided into an episternum and in epimeron. He accounts the absence or reduction of pleurites in the prothorax of other beetles due to the absence of flying appendages on the prothorax. This reasoning is not very sound because prothorax does not carry wings in other insects also. The *coxal cavities* (Figs. 2,7A. *lcxc*) are surrounded by membrane. At the anterior border of each of the coxal cavities is situated the *trochantin* (Figs. 2,7A, 9E. *ltrn*) which is a curved rod-like structure half exposed outside the membrane and half lying laterally inside the pronotum. Campau (4) considers the trochantin as the definite pleural element. According to Snodgrass (14) trochantin represents the anterior remnant of coxopleurite. The greater part of the ventral side of prothorax behind the fore-legs is membranous. There is thus no postcoxal sclerotization.

Pterothorax:—The *pterothorax* which includes the wing bearing *mesothorax* (Fig. 3, 2*th*, 3*th*) is greatly complicated and highly modified. With the loss of flight function of the forewings and their modification into the elytra, the mosothorax is much reduced but considerably modified. The metathorax, however is much larger and generally conforms to the pattern of the typical wing bearing segment. However, the endophragmal skeleton is highly developed in order to provide attachment for the muscles of the hindwings.

Mesothorax.— The *mesothorax* is smallest of the three thoracic segments. Its *dorsum* (Figs. 6, 8, 9, BD. 2*T*) is a separate small piece while its venter is fused with the venter of the metathorax to form the *plastron* of Snodgrass(14).

The *mesonotum* (2*T*) is much reduced and is merely a transverse rectangular plate, almost completely hidden underneath the posterior hood-like extension of pronotum (*IT*). It is exposed and covered as the pronotum moves forward and backward. Unlike the wing-bearing segments of most pterygota the tergum of mesothorax is not divided into an anterior plate or notum and a smaller posterior plate or postonotum (pseudonotum of Verhoeff and postscutellum of others). It is divided into *prescutum* (Fig. 9. 2*prsct*) *scutum* (2*sct*) and *scutellum* (2*scl*). No sutures however mark the boundaries of these regions. The prescutum and scutum are covered by the pronotum while the scutellum covers the anterior mesial areas of the elytra during rest. The prescutum is the anteriorly and ventrally inflected sclerotized piece (Figs. 8, 9BD. 2*psrsct*). It has an *anterior phragma* (*lphr*) which is divided into two narrowly separated lobes. The phragma is turned behind to form the two lateral pouch-like structures. The scutum (2*sct*) is a broad rectangular piece and has a mid-line in apposition of the mid-line of the pronotum. The median inflection of this line is a small *median plate* (Fig. 6 B. *lsemp*). The mesoscutum bears a pair of anterior and a pair of posterior notal wings processes. Its lateral margins (Fig. 7A. 2*sctlphr*) are directed behind to articulate with the lateral margins of the prescutum (3*prsct*) of metathorax. The scutellum (2*scl*) is a median narrow area whose posterior wall is inflected down and anteriorly where its margin gives attachment to the large membrane between the meso and metanotum. Imms (10) in his account of the thorax of Coleoptera writes 'the tergum of the thoracic segments is divisible into prescutum, scutum and scutellum. The latter sclerite is median in position and divides the scutum into two separated plates.' In the bettle here described the *mesoscutellum* (2*scl*) is median but it does not divide the scutum in separate plates. The mesopleuron is represented by the *mesepisternum* (2*eps*) and *mesepimeron* (2*epm*) which are in very close contact with the *mesopreepisternum* (2*preps*) and the similar sclerites of metathorax. The pleural sclerites are well developed and separated by a well marked *pleural suture* (Fig. 3*pln*) which runs diagonally from the base of midcoxa to the forewing base. The pleural suture is inflected internally to form the pleural ridge. The dorsal prolongation of the episternum and epimeron is modified to support the base of the elytron. Their lateral margins bound the coxal cavities of the mid legs. The *mesopimeron* (2 *epm*) bears a small condyle which fits in the corresponding cavity of the coxa. In between the pleurite and coxa is enclosed a membranous area containing a small *trochantin* (*trn*). An outer lateral fold of mesepimeron covers the antero-lateral margin of *metaepisternum* (3*eps*). Just above the coxa it also articulates with the *metapreepisternum* (3*preps*). Khatib (11) mentions that in *Galerucella* the mesepimeron is connected with the *metaeusternum* and *metaepisternum*. Such a condition is not found in this beetle. What Khatib (11) and Snodgrass (14) call as *metasternum* is actually the preepisternum or the coxal sclerotization of the segment. The true sternum or eusternum of Snodgrass is much reduced in the beetle here described and is not apparent externally. Behind and mesially the episternum (Fig. 7A. 2*eps*) of the two sides join together. Just behind this joint is a triangular area which is the preepisternum (2*preps*) of mesothorax and is posteriorly fused with the mesosternum or eusternum of Snodgrass. The latter is small and bears a pair of *furcal arms* (Fig. 7B. 8B. 2*stnap*) running upwards and fusing with the pleural ridge above. At this point it gives off an anterior process for the attachment of mesonotal muscles. The pleural elements are not subdivided into *katepisternum* and *katepimeron* or an *anepisternum* and an *anepimeron.* The presence of furca, according to Snodgrass (14) should demarcate the eusternum into a basisternum and a sternellum. But due to specialization of thorax in the beetle such a demarcation is not met with and the furca bearing sternum is directly connected to the preepisternum of metathorax. On the dorsal and outer sides of the prescutum of mesothorax is a long sclerite the *basalare* (Figs. 3,6. 2*bal*) and lying just behind the mesepimeron is a rectangular piece the *subalare* (2*sal*).

Metathorax.—The *metathorax* (Fig. 3. 3*th*) is the most highly developed of the three thoracic segments because the hind pair of wings arise from this segment. The elytra have lost their function of flight and the hind wings have to act as active agents in the flight. There are several sutures externally and corresponding ridges internally. Due to the presence of all these structures the metathorax shows many peculiarities of its own.

The metathoracic dorsum is divided into *notum* (alinotum of Snodgrass) and a *postnotum* (Fig. 3 *pt*). The notum is divided into a prescutum, scutum and scutellum which are marked off from one another by sutures. The *prescutum* (Figs. 3, 8. 3*prsct*) is separated anteriorly from the mesonotum (29) and posteriorly by the rest of the metanotum (3*T*) by a wide *membranous area* (ma). It is a dorsally arched strip broad laterally but very narrow in the middle. Anteriorly and posteriorly in the mid-line it is concave. The median portion is covered by the scutellum of the mesothorax (2*scl*) while the anterior and posterior parts are articulated with the scutum (2*sct*) of mesothorax. The broad lateral parts are partially covered behind by the *prealar bridge* (Fig. 6A. *prwb*) of the scutum. In a median longitudinal section it is seen that an anterior *acrotergite* (Fig. 8. *atg*) is attached to the prescutum. It is separated from the prescutum (3*prsct*) by an *antecostal suture* (*ancn*). The antecostal suture is flexed ventrally into a long vertical plate. This plate (Fig. 9AC) when seen in cephalic view shows division into two parts, a more dorsal region (Fig. 9AC. 3*prsct*) and a ventral region divided into two lobe-like *phragma* (2*phr*) to which the dorsal longitudinal muscles are attached. The significance of the dorsal plate is that it is composed of two closely jointed walls. This double nature of the plate can only be seen if the metathorax is soaked in KOH and the acrotergite is pulled out. (Fig. 9C). By doing so the single dorsal plate divides into two plates an anterior and a posterior. The anterior plate is the inflexed part of the prescutum. So actually the prescutum and acrotergite are not as narrow as they are seen in a dorsal view. This point is of great interest as it has been overlooked by Snodgrass (13) in the description of the thorax of beetles. He designated the whole central section of the scutum and a narrow anterolateral region bearing the *anterior notal wing process* (Fig. 6A. *atwp*) as to prescutum and has termed the minute prescutum, the acrotergite and the antecostal phragma collectively as the prephragma. He failed to recognise that his prephragma was composed of the anterior phargma of metanotum as well as the anterior acrotergite and the posterior metaprescutum. This threw the interpretation of these structures in the beetle in disorder. Instead he described the bulges in the scutum as prescutum because of their distinction due to very sharp grooves behind them. That this interpretation of Snodgrass is probably incorrect was also pointed out by Campau (4) in his discussion of the morphology of *Chauliognathous pennsylvanicus*.

The scutum is the most characteristic sclerite in Coleoptera and is the largest of all metathoracic tergites. Its anterior and posterior lateral borders are respectively known as the anterior and posterior notal wing porcesses (Fig. 6A. *atwp, ptwp*) to which the wings are attached through membranes. The scutum is divided into two lateral halves by the anterior prolongations of the scutellum. There are two *scutoscutellar sutures* (Fig. 6A. *sctln*) one on either side of the scutellum (*3scl*). Internally this suture forms a strong V-shaped ridge which strengthens the notum. Each lateral half of the scutum is divided by an *intrascutal suture* (*lsn*) into an anterior narrow area and a posterior broad area. Internally this suture has a ridge called the *intrascutal phragma* (Fig. 6B. *islphr*). This is a very characteristic feature of the metanotum of the beetles. In the description of *Galerucella*, Khatib (11) has figured that the anterior area is broader than the posterior which is not the case here. The *scutellum* (*scl*) has undergone considerable modification from the generalized type. It is much produced forward, its apex actually dividing the scutum into two lateral regions. The forward prolongation has a median broad groove and two lateral areas the *alacrista* (*acr*) or longitudinal ridges to which the elytra are hooked when at rest. The median area has wide groove while the longitudinal furrows or alacrista are elevated areas broad anteriorly and narrow posteriorly. These longitudinal furrows also occur in some insects viz. Mantispidae and Hymenoptera where Snodgrass (14) has called them as notaulices or convergent furrows. Khatib (11) has used this term while describing the anatomy of *Galerucella*. Campau (4) suggests that this term conveys the same sense and there seems to be no reason to hesitate in calling these furrows in the beetles, the convergent furrows.

The *metascutellum* (Fig. 6 *3scl*) is followed by the *postnotum* (*pt*) (*postscutellum* of some authors). This is intimately attached to the first abdominal segment behind the scutellum (*3scl*). As a result of this the first abdominal segment comes in very close contact of the pterothorax. It gives into the body cavity a bilobed *posterior phragma* (3 phr). The ventral area consists of a large *preepisternum* (Fig. 7 *3preps*). When viewed from the side, it is seen that the pleuron has undergone a shift in axis and lies diagonally. Anterior to the pleuron is a membranous area which connects it with the epimeron (*2epm*) of mesothorax while ventrally it is attached by a very narrow membrane to the preepisternum (*3preps*).

It consists of the usual sclerites i. e. a ventral episternum (3*eps*) and a dorsal epimeron (3*epm*). Both the pieces extend as far as the posterior margin of the first abdominal segment and anteriorly extend dorsally to form condyles which help articulation of the hind wings to the anterior *notal wing processes* (Fig. 6A. *atwp*). These are called the pleural wing processes. The *epimeron* (3 *epm*) is smaller than the episternum (3 eps) and is produced dorsally into a small piece which extends very near up to the anterior margin of the postnotum. The two pieces are separated externally by a *pleural suture* (Fig. 3 *pln*) which internally forms a ridge, the *pleural ridge* (Fig. 8, 3 *phr*). The pleural elements are not subdivided into anepisternum and katepisternum or anepimeron and katepimeron. Bostic (3) in his account of *Calosoma* describes the division of epimeron into an anepimeron and katepimeron. Khatib (11) mentions that in *Galerucella* the epimeron is a very small sclerite reduced merely to a line. No true sternum is visible in *Mylabris*. Its place is occupied by a large trough-like plate, the preepisternum (Fig. 7. 3 *preps*) forming the ventral sclerite of the metathorax. It

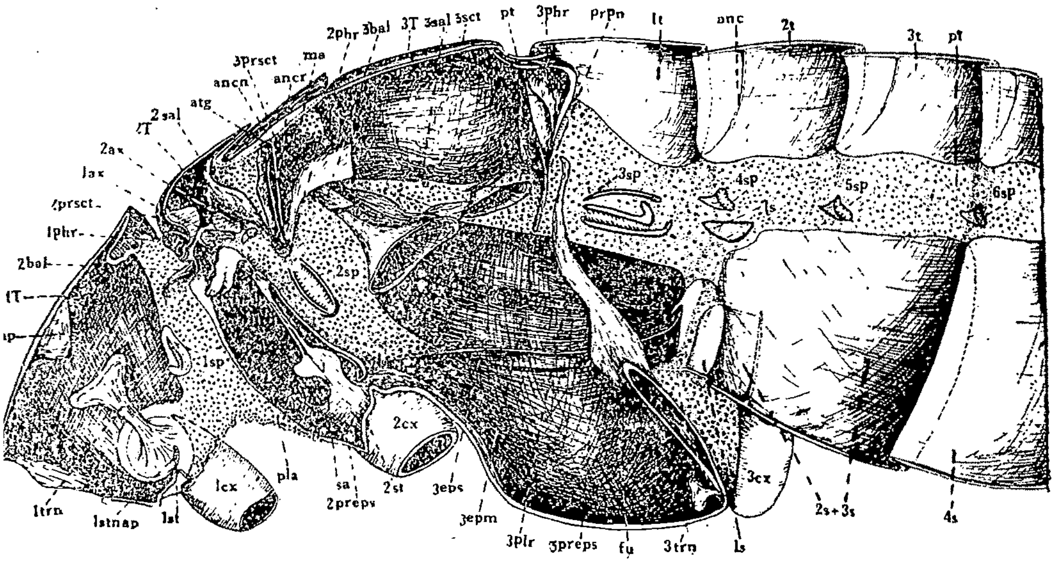


FIG. 8. Skeleton of thorax. Vertical section of thorax and base of abdomen to show the skeleton from the inner aspect. *anc.* antecosta; *ancn.* antecostal suture; *ancr.* antecostal ridge; *atg.* acrotergite; *fu.* furca; *ls.* laterosternite; *ma* membranous area; *pl.* pleuron; *pla.* pleural apophysics of mesothorax; *prpn.* downwardly directed process of postnotum; *sa.* sternal apophysis of mesothorax; *semp.* endoskeletal plate; 1.2 *ax.* first and second axillary sclerites of mesothorax; 2 *bal.* basalare of mesothorax; 3 *bal.* basalıe of metathorax; 1.2.3 *cx.* coxae of fore, mid and hind legs; 3 *epm.* metepimeron; 3 *eps.* metepisternum; 1 *phr.* phragma of mesothorax; 2.3 *phr.* anterior and posterior phragma of metathorax; 2.3 *preps.* preepisternum of meso and metathorax; 2.3 *prset.* prescutum of meso and metathorax; *pt.* postnotum; 2*s* 3*s.* fused sternal plates of second and third abdominal segments; 2.3 *sal.* subalare of meso and metathorax; 3 *sct.* scutum of metathorax; 1.2 *sp.* first and second thoracic spiracles respectively ; 3-6 *sp.* first to fourth abdominal spiracles; 1.2 *st.* pro and mesosternum; 1 *stnap.* prosternal apophysis; 1.2.3 *t.* first, second and third terga of abdomen; 1.3 trn. trochantin of fore and hind legs; 1.2.3 *T.* pro, meso and metanotum respectively.

is very intimately connected with the *mesosternum* (2*st*) and *mesepisternum* (2*eps*). This closely jointed structure has been termed *plastron* by Snodgrass (14). In the midventral region anteriorly it bounds the *coxal cavities of midlegs* (2*cxc*) while posteriorly it becomes very broad and bounds the anterior margin of *coxal cavities* of hind legs (3cxc). There is a distinct line called the *discriminal line* (*disc*). A similar line has been termed as enigmatic longitudinal suture by Khatib (11) which consists of a ridge inside. The median posterior region of the discriminal line has two small condyles attached to the mesial margins of the hind coxae. The area designated here as preepisternum has been called as sternum by Khatib in *Galerucella*. But Campu (4) in the description of *Chauliognathous* has shown that the large ventral plate is not sternum but preepisternum which is the greatly modified and expanded bases of the subcoxal segments of the hind legs. A small stalk-like structure runs dorsally and medially from the posterior end of discriminal line which should be called as furcasternum or sternellum according to the terminology of Snodgrass (14). Internally it gives off two long divergent arms called the *furca* (Fig. 8, *fu*) which are connected by muscles to downwardly directed processes of the postnotum (*prpn*). The *metafurca* is very highly developed in all Coleoptera. The coxal cavities of hind legs (Fig. 7A. 3*cxc*) unlike the mid-coxal cavities (2*cxc*) are bounded by a large membrane which itself is connected posteriorly by the first abdominal sternum (*ls*).

The *trochantin* of the metathorax is represented by a muscle disc situated on the outer side of the base of the furca (Fig. 8 3 *trn*). A trochantin as found in the fore and mid legs is not usually found in the hind legs of the beetles. Snodgrass (13) has mentioned that trochantin is not present in the metathorax of beetles. Campau (4) reports that it is present as a small plate in a Cupesid beetle. Its absence has also been noted in *Calosoma* by Bostick (3).. Situated anteriorly in the metathorax is a *basalare*(Figs. 6, 8 3*bal*) and situated at the base of the wing behind the first axillery sclerite is a very small *subalare* (3*sal*). These sclerites are present as muscle discs.

ABDOMEN

The *abdomen* is cylindrical and tapers posteriorly. Its exoskeleton consists of sclerotized pieces of dorsally convex *terga* (Fig. 8 *t*)and ventrally concave *sterna* (*s*) connected with one another dorsally and ventrally by thin intersegmental membrane and laterally with the pleural *membrane* (*pln*) which lodges the *spiracles*(*sp*). Sterna are broader, more heavily sclerotized and hairy than terga.

In both the sexes it consists of nine tergal and eight sternal plates (Fig 3). Eight terga are readily visible (Fig. 1), the ninth is hidden by the eighth as it lies terminally dorsal to the rectum. Similarly seven sterna are visible externally; the first sternum is hidden by the posterior border of metapreepisternum and the succeeding sternum.

The first abdominal segment is very intimately attached with the metathorax. It has a tergum (Fig. 8, *lt*) and a sternum (*ls*). The antecosta of the first abdominal tergum bears a pair of *phragmatal lobes* (3*phr*) and the acrotergite is much enlarged, forming the *postnotum* (*pt*) of the metathorax (postscutellum of some authors). As this area has become detached from the first abdominal tergum by a membranous area in between and has become united with the metathorax, the phragmatal lobes are called *third* pair of *phragma* (3*phr*). Inspite of this specialization the first abdominal tergum is a sclerotized rectangular plate as big as the second. It does not bear any internal ridge for the attachment of muscles. The first abdominal sternum (*ls*) a very small plate attached behind the furca. It is narrow in the middle but broad at the outer ends. It does not join with the posterior margin of the venter of the metathorax but is a little above it. Therefore the anterior abdomen is not as wide as the posterior thorax. The first abdominal tergum (1*t*) covers the anterior border of the second while the first sternum is covered by the anterior border of the succeeding sternum (2s-3s). The first abdominal sternum does not lie directly below the first tergum but is shifted behind. The first tergum has ventrally the posterior preepisternum while laterally it has the metathoracic pleurites (3 *eps*. 3 *epm*) and the large pleural membrane containing the big first abdominal spiracle (3*sp*). The second abdominal tergum (2*t*) is nearly equal to the first and its anterior margin is telescoped below the posterior border of the first. Anteriorly it has the *antecosta* (*anc*) in the form of a semicircular ridge divided into two lateral parts to give attachment to the dorsal longitudinal muscles. Its sternum is compactly fused with the sternum of the third segment to form a large compact plate (2*s*- 3*s*) with an antecosta near the anterior margin. Anterolaterally it has a pair of small crescentic *laterosternites* (*ls*), which Snodgrass (14) considers as part of definitive thoracic sternum, derived from the sternopleurite of the subcoxa. The third abdominal tergum (3*t*) is nearly as large as the second. The second and third segments have ventrally a fused plate formed by the second and third sterna and laterally a large membranous area, *pleuron* (*pln*) containing the second and third abdominal spiracles (4*sp*. 5*sp*.) below the lateral margins of the terga. The posterior border of the second and third abdominal plate covers the anterior border of the succeeding sternum unlike the first which is covered by it (connate plate). The fourth and fifth segments are identical in the possession of nearly similar terga and sterna. In the sixth segment the tergum is normal but somewhat smaller than the preceding terga but its sternum is broader and longer than the preceding sternum. Posteriorly it is produced so as to partly cover the venter of the seventh abdominal segment also. The tergum and sternum of the seventh segment are narrower but more sclerotized than the preceding terga and sterna. The pleural membrane is reduced and the spiracle that opens in it is the seventh abdominal spiracle (9*sp*) which is the smallest of all. The eighth segment which is smallest of all has both the tergum and the sternum. It encloses the anal and reproductive openings as well as the external genitalia. In a cross section of the abdomen anterior to the eighth segment it is seen that the lateral border of the sternum covers the lateral border of the tergum; but in the eighth segment this arrangement reverses and the lateral border of the tergum covers the lateral border of the sternum. The ninth tergum (Fig. 3 *ept*) is membranous with sclerotized hind margin and lies like a flap dorsally over the rectum. Below it are the paired *paraprocts* (*papt*). The ninth sternum is modified in the male to form the *spiculum*, while in the female it is represented by its appendage, the second valvifer (Vlfr) (Fig. 3 *vlfr*).

The number of segments which enter into the composition of the abdomen and their homologies are difficult to determine. In *Chauliognathous*, according to Campau (4) the abdomen is composed of ten evident segments in both sexes. The first segment is represented by the tergite and lacks any recognizable vestige of the sternite and tenth and eleventh are fused and mostly membranous. In *Calosoma* the abdomen is ten segmented in both sexes but tenth tergum is reduced and tenth sternum is absent. First two sterna are missing in males and first sternum in females. Blood (2) does not mention anything about the segmentation of abdomen in *Pyrota mylabrina*. Khatib (11) describes that in *Galerucella* the abdomen has nine segments, the ninth tergum being periproct. The terga of the first two segments are visible while their sterna are absent due to the enlargement of the metasternum (preepisternum). According to interpretation of Snodgrass (14) the abdomen of the beetle is composed of eleven segments. First to eighth segments have each a tergum and a sternum. The sternum of first segment is small while those of second and third segment are fused or connate. The tergum of ninth segment is absent. Its sternum is modified into spiculum gastrale in male and is absent in female. The tenth segment is represented by membranous area surrounding the anus. The eleventh segment has the tergum modified into epiproct and paraproct, but no sternum. If the interpretation of Snodgrass is accepted the abdomen shows a very simple structure except the fact that two sterna are connate. In other beetles it is seen that the abdominal segments show a tendency towards reduction by the fusion of segments as seen here in the anterior region of the abdomen and also by the absence of certain segments behind. Arrow (1) regards this reduction of abdomen in the beetles as adaptation to various modes of life.

APPENDAGES OF THE THORAX

All the three thoracic segments bear each a pair of *legs* (Fig. 1. *b*) while the mesothorax and metathorax bear each pair of *elytra* (*fw*) and *wings* (*hw*) respectively. The legs are fitted for walking and clinging to the branches. The fore and mid legs are nearly of equal size (Fig. 4 AB) and the hind legs (G) are the longest. The fore legs are attached to the *coxal cavities* (Fig. 3-1 *cxc*) in the ventral membrane between the pro and mesothorax thus anterior to the first pair of thoracic spiracles and behind the prosternum (1*stn*). They are widely separated by the membrane. The mid legs are articulated to the coxal cavities of mid legs (2 *cxc*) by very narrow membrane on either side of the small mesosternum and are surrounded anteriorly by the preepisterna of mesothorax and ltaerally by the mesepimeron and mesepisternum while behind by the preepisternum of metathorax. The hind legs are situated in the coxal cavities (3 *cxc*) and are attached behind the preepisternum and anterior to the abdomen. The anterior margin of the hind coxa is attached all through the posterior margin of the preepisternum while its posterior rim is continuous with the membrane connecting it with the abdominal sterna (Fig. 7A).

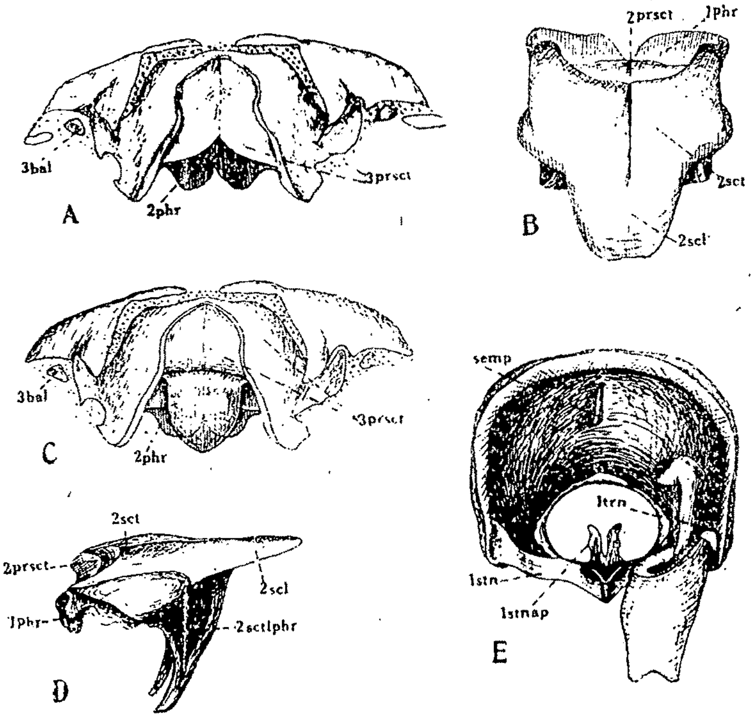


FIG. 9. Thoracic sclerites. A. Metanotum in cephalic view. B. Mesonotum in dorsal view. C. Metanotum in cephalic view with the acrotergite opened out. D. Mesonotum in lateral view. E. Prothorax in caudal view with right coxa *in situ*. *semp*. endoskeletal plate; 3 *bal*. basalare of metathorax; 1 *phr*. phragma of mesothorax; 2 *phr*. anterior phragma of metathorax; 2.3 *prsct*. prescutum of meso and metathorax; 2 *scl*. scutellum of mesothorax; 2 *sct*. scutum of metathorax; 2 *sctlphr*. posterolateral prolongations of mesonotum; 1 *stn*. *prosternum*; 1 *stnap*. prosternal apophysis; 1 *trn*. trochantin of ore leg.

All the legs are clothed with hairs which are more prominent on the outer side and distal ends. Each leg (Fig. 4A,B,C) is composed of a stout *coxa* (*cx*) a small *trochanter* (*tr*), a long *femur* (*fm*) a *tibia* (*tb*), *tarsus* (*ta*) and a *pretarsus* (*pta*) . The tibia at its distal end bears a pair of spine-like *tibial spurs* (C. *tsp*). There is no trace of an *arolium*. The tarsi are five jointed in the fore and mid legs and four jointed in the hind legs. All are densely clothed by fine pubescent hairs. They are thicker distally and narrow proximally. The terminal segment of the leg is the pretarsus (*pta*) which includes the *claws* or *ungues* (*un*). A median basal plate, the *unguitractor* plate of Snodgrass (14) and *tractor plate* of Khatib (11) (*untp*) is found medially. Arising from its distal end is a median lobe the *empodium* (*emp*) bearing long bristles. The claws have on their outer surfaces a long *appendage* (*una*) that looks like a duplicate claw.

The coxal cavity of fore leg is small, of mid leg bigger and hind leg biggest elongated and separated from the coxal cavity of the othr side by the base of the metathoracic furca. The coxae (*cx*) of the fore and mid legs are nearly equal. The fore coxa is nearly round with a long process while the mid coxa has flat and depressed posterior surface and a very short process. Both are capable of free movement on all the sides. The hind coxa partly overlies the first abdominal sternum and is articulared with its outer end by a process at its inner end to the base of the furca. Anteriorly each coxa is articulated through a narrow membrane to the broad posterior margin of the preepisternum of metathorax. Thus unlike fore and mid coxae it rotates about an axis passing through the above mentioned two points. The outer surfaces of the hind coxae show depressed concave surfaces into which fit the inner convex parts of the femur. The fore and mid legs are articulated to the coxal cavities by a trochantin (*trn*).

The trochantin of the fore leg (Figs. 2,4,7. 1*trn*) is a long rod-like structure which at one end fits into the margin of coxa and at the other by a flat disc-shaped structure to the lateral wall of the prothorax. The proximal half of the trochantin is hidden inside the body while the distal half can be seen outside. The trochantin of the mid leg (2*trn*) is a small triangular piece with its apex fitting at the margin of the coxa and its base to the preepisternum of the mosothorax. The trochantin of the hind legs (3*trn*) is represented by a *trochantinal disc* articulated by a narrow stalk to the side of the furca of metathorax. The trochantin is regarded as an anterior remnant of the coxopleurite by Snodgrass (14).

The *trochanter* (*tr*) is triangular in all the legs. It is smallest in fore leg and larger in the mid and hind legs where it is more rounded than in the fore leg. It gives attachment to the femur which is the stoutest part of the leg. The femur (*fm*) is followed by a tibia (*tb*). The latter has a narrow proximal end by which they are attached to the broad distal ends of the femur. The distal end of tibia is broad and has on the inner end a pair of tibial spurs (*tsp*). The tibia is followed by tarsus (*ta*). The distal tarsal segment is longest in all the legs. Its dorsal and ventral walls at its distal end are separated by narrow membrane. The proximal tarsal segment is also nearly as long as the distal segment to which the pretarsus (*pta*) is attached.

Wings.—There are two pairs of wings situated on the meso and meta thorax. The first pair of wings, called elytra play no active part in flight and serve to protect the greatly folded and delicate second pair of wings during repose. During flight the elytra are opened to form a right angle with the body so as to give full freedom to hind pair of wings for movement.

Elytra.—Each *elytron* (Fig. 1.*fw*) is moderately hardened, oblong, finely rugulose and semi-matt, with the sides somewhat sloping. It is banded bright red to black The bands do not show uniformity in arrangement. In a typical elytra there are three black and three red bands. The red bands are broader than the black. At the base is a narrow black band and at the apex a broad black band. The boundaries of the band are marked in a zig-zag manner. The bands of two sides are almost symmetrical but differ in very minute details. When the elytra of both the sides are folded they meet in the mid-line and the bands of one side appear continuous with those of the other thereby making uniform strips of colour. A very interesting feature is that the black bands are thickly clothed with hairs while the red are sparsely clothed. There are three obscure striae on the elytra. On the ventral surface corresponding to the striae there are three conspicous carinae. The first carina from the outer margin is branched. Basally each elytron is abruptly narrowed and produced into a truncated process, the mesial margin of which is somewhat notched and fits into the scutellum through a narrow membrane, when the two elytra are closed over the dorsum.

Axillary sclerites.—Behind the basal process lying in the alary membrane are two sclerites. The first (Figs. 8, 10. 1*ax*) articulates with elytron on one side and with the mesonotum on the other side. The second *axillary sclerite* (2*ax*) lies behind the first. Khatib (11) has mentioned three axillary sclerites in *Galerucella.*

Hind Wings.—The second pair of *wings* is borne on the metathorax. In repose the wings are folded in a complex manner and are completely covered by the protecting elytra.

Each wing is widest in the middle and tapers on the outer side. Medially it is rounded. When stretched it partly covers the lateral parts of postnotum and first abdominal tergum. The apex of the wing is more membranous than the base and the entire surface is covered by fine hairs. The wing venation is of of Cantharid type. The veins in the apical area have mostly disappeared and at the proximal end have become more or less crowded and fused. This is the result of the characteristic pattern of creasing and folding of the wing. The interpretation of the veins is after Grahm (13). The veins *c*, *Sc* and *R* are crowded at the costal border of the wing. Before reaching the apex a pterostigma is formed. *R* is much thickened. Behind *Rs* is distinct. *Cubitus* (*Cu*) and anal veins are characterstically united at the inner end. At the outer end between the fused veins of *Costa*, *subcosta* and *radius* (Fig. 10A. $C+Sc\ R_1$) and cubitus (*Cu*) is a transverse vein which does not run straight due to a small curve anteriorily. This represents the recurrent vein of *Radial* branch (R_1) and *Medius* (*M*) which have become transverse and form the *radiomedial cross vein* (*rm*). The medial vein is represented by a small inner branch (*M*) and a small outer branch (M_1+2). A downward prolongation extending to the outer side is called the $M_{3+4}+Cu$, because Cubitus (*Cu*) has also fused with (M_{3+4}). This is a strong vein which extends the length of the wing. This gives a characteristic appearance to the outer part of the wing. A dagger-like vein hangs down from the outer margin of $C+Sc+R_1$. This vein is not mentioned by Grahm in his description of the wing of meloid beetle *Pomphopie sayi*. This may be considered as a branch of the $C+Sc+R_1$. There is definite arculus (arc) on the inner side of the wing and near its base. This is bounded anteriorly by R_1 and posteriorly by

Cu. On its inner side is a small thickened transverse sclerotized part. There are four anals namely A_1, A_2, A_3 and A_4. All run upto posterior margin of the

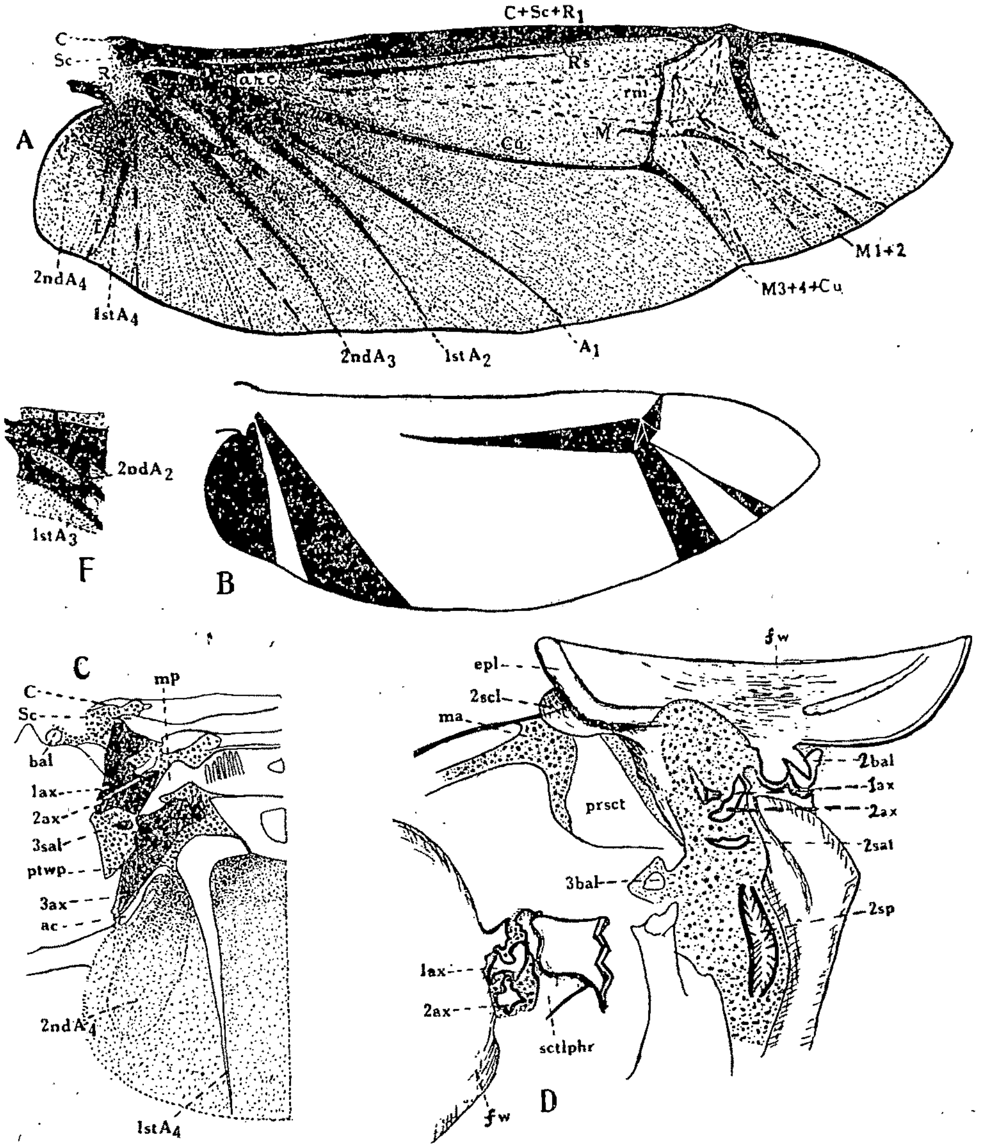


FIG. 10. Wings. A. Hind wing with the veins (continuous lines) & lines of folding (broken lines). *arc.* arculus; A_1 first anal; C. costa; $C+Sc+R_1$ Costa, Subcosta and radial branch; *Cu.* Cubitus; *M.* media; M_1+2 media 1+2; $M_3+4+Cu.$ media 3+4+cubitus; *R.* radius; *rm* radio-medial cross vein; *Rs.* radial sector; *Sc.* subcosta; *Ist* A_2 first branch of the second anal; *Ist* A_4 first branch of fourth anal; *2nd* A_3 second branch of third anal; *2nd* A_4 second branch of fourth anal. B. Hind wing with the pattern of folding. The shaded areas are folded below when the wing is flexed. C. D. Figures showing the wing base sclerites. *ac.* axillary cord; *C.* costa; *mp.* medium plate; *ptwp.* posterior notal wing process; *Sc.* subcosta; *1st* A_4 first branch of fourth anal; *2nd* A_4 second branch of fourth anal; 1.2.3 *ax.* first, second and third axillary sclerites of hind wing; 3 *bal.* 3 sal.

wing. First anal (A_1) is a simple vein with no branches. It is the longest of all anal veins. Second anal (A_2) has two branches viz. 1st A_2 and 2nd A_2. First branch of second anal (1st A_2) is long while second branch (2nd A_2) is a small vein. Third anal has two branches viz. 1st A_3 and 2nd A_3. First branch of third anal is small while *second branch* (*2nd* A_2) is long. *Second branch of second anal* (*2nd* A_2) and *first branch of third anal* (*1st* A_3) fuse together enclosing a membranous area and then run for a short distance as a spur between the first branch of second *anal* (*1st* A_2) and second branch of third anal (2nd A3). This spur has been termed as 'chevron-shaped structure' by Grahm (13). Fourth anal also has two branches viz 1st A_4. and 2nd A_4. The first branch of fourth anal (1st A_4) is a small but definite vein while the second branch (2nd A_4) is not a definite vein as found in *Pomphopie*, but is a oval sclerotized part of the vein which on the inner side takes the form of a broad small vein connected to the *axillary cord* (*ac*).

The wing of *Mylabris* shows many differences from the rest of Heteromera. The differences result from the reduction. The radial cell is lost and the outer ends of the radial and medial recurrents have become nearly transverse and continuous with the radiomedial cross vein. In the anal region there are four simple anal veins with a chevron-shaped structure between the second and third anals, towards the base. At first sight this arrangement seems unique but is easily derivable from the normal heteromerous type by the loss of the lower side of the wedge cell, veins *2nd* A_3 and *3rd* A_1 of the hypothetrical wings of Coleoptera.

Forbes (9) has described the venation of *Pomphopie sayi* (*Lec*), a species of the Meloidae very closely related generically with *Mylabris pustulata*, the two genera being separated only on the basis of a slightan tennal difference. In *P.sayi* the radial sector seems to have dropped out. The unstable media seems to have gone in *Mylabris* as in *Pomphopie*. Blood (2) describes in the wing venation of *Pyrota* that the wing venation shows some variations in the sense that there is in some cases an atrophied cross vein between the first anal (A1) and the first branch of the second anal (1st A_2). In some cases it is absent in both the wings; present in both the wings or it may be present in one wing and not in the other in the same beetle. Such a variation is not seen in *Mylabris*. When the wing venation of *Mylabris* is compared with the wing venation of *Epicauta pennsylvanica* it is seen that it resembles much. However Snodgrass (14) has named some veins differently. What are labelled in *Mylabris* as 1st A_2 and

basalare and sublare respectively of metathorax. D. Wing base sclerites. *fw.* elytra; 1.2 *ax.* first and second axillary sclerites of fore wing; 2 *sctlphr.* posterolateral prolongation of mesonotum; E. Elytra lifted up to show the axillary sclerites. *epl.* epipleura; *fw.* elytra; *ma.* membranous area; 1.2 *ax.* first and second axillary sclerites of fore wing 2.3 *bal.* basalare of meso and metathorax respectively; 3 *prsct.* prescutum of metathorax; 2 *sal.* subalare of mesothorax; 2 *scl.* mesoscutellum; 2 *sp.* second thoracic spiracle. F. Part of venation highly magnified. *1st* A_3 first branch of third anal; *2nd* A_2 Second branch of second anal.

2nd A_3 are labelled as first vannal and second vannal veins respectively. The first A_4 and 2nd A_4 of *Mylabris* is labelled as 1st jugular and 2nd jugular.

Folding mechanism of the Wing.—One of the most striking features characterizing the wings of the Coleoptera is the fact that they are not only folded longitudinally but also have at least one transverse fold.

The folding mechanism is shown in Fig. 10 B. The shaded areas are tucked underneath. The wing is folded at different places and the folds are not only longitudinal but also transverse. This is one of the advantages in folding the wings because it results not only in narrowing but also in shortening of the wings when they are folded against the body. This brings the wings under the elytra for protection which is essential to an insect where an unprotected wing membrane would almost certainly be torn.

The folds follow the lines of least resistance between veins nearly running parallel with and often very close to a vein thus bringing about a mutual adjustment of position between folds and wing veins. There are longitudinal folds between $C+Sc+R_1$ and cubitus, and four folds in the apical region of the wing. Near the pterostigma there is a complicated system of folding. In the anal region the wing is folded at three places: on the inner side of 2nd A_3 and on the either side of 1st A_4.

Axillary sclerites.—Each wing is hinged at its base to the anterior and posterior wing processes (Fig. 6A, *atwp.ptwp*) of the notum. The wings are not directly articulated with the thorax but are interposed by a set of small articular sclerites or axillaries or wing base sclerites lying in the alary membrane. These sclerites intervene between the proximal ends of the veins and the wing processes of the thorax. In each wing there are three axillary sclerites. The first axillary (Fig. 10C. lax) is a large sub-trapezoidal plate between the subcosta of wing and the anterior notal wing process of the tergum. Its inner margin somewhat overlies the apex of the anterior notal wing process of the tergum. Its inner margin somewhat overlies the apex of the anterior notal wing process. The second sclerite (*2ax*) is a triangular piece lying between the median plate (*mp*) and the first sclerite. The third sclerite (*3x*) is a large, boot-shaped plate between the posterior part of the wing base and the posterior notal wing process. It articulates with the posterior notal wing process mesially behind and with the median plate (*mp*) infront. This sclerite is continuous with the base of the cubitus vein. The posterior edge of the basal membrane of the wing is usually thickened forming the axillary cord (*ac*) which is continuous with the posterior edge of the alinotum.

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BETHYLOIDEA (HYMENOPTERA) FROM INDIA*

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This paper summarizes the results of my four years' study of the Bethyloidea from India. The type specimens of the new forms described here are being deposited in the collections of the Department of Entomology, Indian Forest Research Institute, Dehra Dun.

I thank Prof. Dr. M.S.Mani, Professor of Zoology and Entomology, School of Entomology, for suggesting me the line of work, for guidance and facilities for work.

Superfamily BETHYLOIDEA

Family DRYINIDAE

Subfamily Dryininae

Lestodryinus guptai, sp. nov.

Female.—Length 4.9 mm. Colour reddish-yellowish-brown. Head reddish-brown, viewed from above length somewhat more than half the width; interorbital very slightly over half the width of the head; eyes dark brown, bare; ocelli same colour as the head, arranged in a nearly equilateral triangle; interocellar half the ocellocular which latter is slightly more than twice the front ocellar; vertex faintly and irregularly coriaceously sculptured, posteriorly margined; viewed in front length four-fifths the width; interorbital distance at the middle of eye slightly less than half the width of the head; length of gena one-third the length of eye; clypeus convex, bulging, brown, apically truncate with a bilipped appearance; frons rugoso-carinately sculptured; face nearly smooth and shiny, on face just above clypeus there is a carina running upto the front ocellus; mandible brown, with reddish-brown apex, 4-toothed. Antennae inserted just above the clypeus on an imaginary line joining the lower orbital borders; 10-segmented; scape slightly less than twice the pedicel; first flagellar three times the scape, 2nd three-fifths the first; third very slightly more than half the first; fourth to seventh tergites become gradually shorter; terminal one and one-third the penultimate, of nearly the same length as the scape and somewhat less than twice the pedicel (Fig. 3).

Thorax: Length thrice the width at the region of the tegulae, pronotum irregularly rugoso-sculptured anteriorly and posteriorly finely coriaceously sculptured; pronotal expansions large with longitudinal carinae towards the base; mesonotum equal to pronotum, irregularly ruguso-carinately sculptured;

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parapsidal furrows deep and complete; scutellum half the mesonotum, with few large irregular rugoso-punctae; metathorax two-thirds the scutellum, finely rugoso-coriaceously sculptured; propodeum one and two-thirds the scutellum and metathorax combined; irregularly reticulately leathery sculptured, lateral marginal, posterior and transverse carinae absent; propodeal spiracles large and lanceolate-oval. Legs reddish-brown with yellowish tinge. Fore coxa very long, tibia one and two-thirds the coxa; metatarsus slightly more than half the tibia; rest of tarsi one and one-third the metatarsus; chela somewhat longer than metatarsus; tibial spur one-seventh the length of tibia (Fig. 4 & 5). Hind coxa two and a half times the trochanter; femur nearly seven times the trochanter, tibia one and one-sixth the femur; larger tibial spur slightly smaller than one-fourth the tibia; smaller one-fourth the larger; metatarsus half the tibia; rest of tarsi one and a half times the metatarsus (Fig. 6). Fore wing length slightly more than thrice the breadth; radius very slightly less than one-sixth the length of the wing; basal somewhat less than two-thirds the radius; transversal less than half the basal; rest of details and hind wing as in fig. 1 and 2. Abdomen reddish-brown, with a short dorsally black petiole, somewhat shorter than the thorax, basally bent, dorsally arched; seven tergites distinctly visible; first three somewhat larger than the rest; tergites impunctate, smooth and shiny.

Holotype: 1 female , paratype 1 female, labelled "On sugarcane, Pusa, Bihar, B.D. Gupta, 2-12-1930."

This species runs close to *Lestodryinus formicarius* (Latreille), from which it is distinguished by the reddish-brown, colour; pronotum being as long as mesonotum and irregularly rugoso-coriaceously sculptured; forewings hyaline with no bands; veins yellowish-brown; pterostigma brown and basal slightly over twice the transversal.

Lestodryinus pyrillae Kiffer

1911. *Lestodryinus pyrillae*, KIEFFER, *Bull. Soc. Metz.*, 27 : 108.
1914. *Lestodryinus pyrillae*, KIEFFER, *Das Tierreich*, 41 : 22.
1942. *Lestodryinus pyrillae*, PRUTHI and MANI, *Mem. Indian Mus.*, 13(4) : 423-425.
1954. *Lestodryinus pyrillae*, KURIAN, *Agra Univ. J. Res.* (*Sci.*), 3(1) : 255.

Female.—Length 3.3-3.9 mm. Colour black, with reddish-brown legs. Head viewed from above length three-fifths the width; interorbital distance slightly less than half the width of the head; eyes brown, bare; ocelli arranged in an equilateral triangle; interocellar distance equal to front ocellar and both slightly less than half the ocellocular; viewed in front nearly triangular length four-fifths the width; interorbital distance somewhat less than half the width of the head; length of eye three times that of gena; vertex depressed; rugosely sculptured, margined, with a faint carina which is nearly complete at the sides; face dull, extremely finely sculptured, with a carina running from between antennae upto the front ocellus; few irregular carinae running longitudinally on the face and traversing frons reach the anterior ocellus; clypeus reddish-brown with darker and somewhat prominent apex, a median longitudinal carina upto a level of about one-fourth the length of eye; mandibles reddish-brown ; 4-dentate; teeth concolouress with rest of mandible; clypeus and mandible covered over by short silvery-white pubescence. Antennae reddish-brown; inserted laterally above the clypeus on an imaginary line joining the lower orbital borders, 10-jointed; scape one and two-thirds the pedicel; first flagellar two and three-fourths the scape; second slightly less than half the first; rest of flagellar joints gradually become shorter; terminal very slightly more than one and a half times the penultimate and somewhat smaller than the scape (Fig. 9).

Thorax: Length nearly thrice the width at the region of the tegulae; pronotum one-third the whole length of thorax; one and one-third the mesothorax. distinctly rugoso coriaceously sculptured; mesothorax three-fourths the prothorax, sculpture nearly the same as in prothorax; parapsidal furrows complete; scutellum three-eighths the mesonotum, finely distinctly rugosely sculptured anteriorly, nearly smooth and shiny posteriorly; metathorax two-thirds the scutellum, sculpture irregular, but smooth for the most part; propodeum slightly longer than pronotum, slightly over four-fifths the mesonotum, scutellum and metathorax combined; irregularly reticulately carinately sculptured, spaces between the carinae roughly rugosely sculptured; propodeal spiracles large, lanceolate. Legs reddish-brown with lighter tarsi. Fore coxa somewhat less than trochanters; femur slightly more than two and one-third the trochanter; tibia slightly less than the femur; tibial spur nearly one-sixth the tibia; metatarsus slightly less than half the tibia and somewhat more than half the rest of tarsi combined; chela one and one-third the metatarsus, slightly less than half the tibia and three-fifths the rest of tarsi combined; rest of details as in fig. 11 and 12. Hind coxa somewhat less than thrice the trochanter; femur six and one-third the trochanter; tibia one and one-fifth the femur, tibial spur one-sixth the tibia; metatarsus slightly less than half the tibia and three-fifths the rest of tarsi combined (Fig. 10). Fore wing length three and one-fourth the width; radius very slightly less than one-sixth the length of the wing; basal half the radial; transversal three-fifths the basal; rest of details and hind wing as in fig. 7 and 8. Abdomen five-sixths that of thorax in the natural bent position; petiolate; basally bent, dorsally somewhat arched; six tergites distinctly visible; tergites smooth and shiny: first three tergites much broader than the rest, then the tergites abruptly become narrower; first tergite the longest and nearly one-third the whole length of thorax; ovipositor sheath reddish-brown, equal to last tergite; ovipositor exserted, but only somewhat more than half the last tergite.

Redescribed from a series of females partly dissected on slide and rest on pin No. 24/B, 62/B, 67/B, labelled : "Baria Farm, Champaran, D. P. Singh, 8-10-1932", No. 30/B, 54/B "Pusa, Bihar, R. B. C. S. Misra, 30-12-1927 and 10-20-1-1928, parasite of *Pyrilla* sp.", and No. 94/B "Bred from *Pyrilla* nymphs, Pusa, Bihar, K. Singh, 30-11-1927".

Male.—Length 2.3 mm. Colour dark reddish-brown. Head viewed from above transverse; ocelli arranged in a broad triangle, interocellar distance three-fourths the ocellocular, which latter is slightly over thrice the front ocellar; eyes brown, bare; viewed in front length six-sevenths the width; interorbital distance four-sevenths the width of the head; length of eye twice that of gena; post-orbital little or nil; mandible brown; bidentate; clypeus slightly convex, apically nearly truncate. Antenna inserted below the middle of face on an imaginary line joining the lower orbital borders; 10-jointed; scape one and one-sixth the pedicel; first flagellar two and two-thirds the pedicel; second slightly over two-thirds the first; third and fourth subequal to second; rest of flagellar joints gradually become shorter, except the terminal which is somewhat more than the penultimate, one and a half times the scape and equal to the sixth flagellar joint (Fig. 16).

Thorax: Length one and three-fourths the width at the region of the tegulae; pronotum two-fifths the whole length of thorax; mesonotum one-third the pronotum; parapsidal furrows complete; scutellum three-fourths the mesonotum; metathorax very short; propodeum slightly shorter than pronotum and one and one-third the mesonotum, scutellum and metathorax combined; propodeal spiracles large and lanceolate. Fore femur twice the trochanter; tibia four-fifths the femur; tibial spur slightly less than one-third the tibia; metatarsus equal to tibia and five-sixths the rest of tarsi combined (Fig. 18). Hind coxa thrice the trochanter; femur nearly five times the trochanter; tibia one and one-sixth the femur; larger tibial spur somewhat more than one-fifth the tibia; smaller three-fourths the larger; metatarsus three-fifths the tibia and five-sixths the rest of tarsi combined (Fig. 15 & 17). Fore wing length somewhat less than two and three-fourths the breadth; radius a little longer than one-fifth the length of the wing; basal half the radial; transversal very slightly less than half the basal; rest of details and hind wing as in fig. 13 and 14. Abdomen slightly shorter than thorax; six tergites distinctly visible; first the largest; rest of them gradually become shorter.

Redescribed from 1 male dissected on side No. labelled : "Pusa, Bihar, 10-12-1928, R. B. C. S. Misra."

Paradryinus kevirae Lal

1939. *Paradryinus kevirae*, LAL, *Indian J. Ent.*, 1(2) : 50-51.
1954. *Paradryinus kevirae*, KURIAN, *Agra Univ. J. Res.*, 3(1) : 256.

Male.—Length 2.9 mm. Colour black, with dark reddish-brown abdomen. Head viewed from above length nearly five-eighths the width, somewhat wider than thorax; interorbital distance two-thirds the width; eyes brown, bare; ocelli reddish-brown, arranged in a broad triangle; interocellar slightly over twice the front ocellar and one and a half times the ocellocular, which latter is slightly less than one and a half times the front ocellar; vertex finely and distinctly rugosely sculptured, margined; viewed in front length five-sixths the width; interorbital distance slightly more than two-thirds the width of the head; length of eye slightly more than twice that of gena; post-orbital distance one-tenth the length of eye; eyes dark brown, bare; frons and face rugosely sculptured with a few irregular carinae, faint median line from anterior ocellus to base of antennae; mandibles reddish-brown with an yellowish tinge; palpi yellowish-brown; maxillary palpi long 5-jointed; labial palpi short. Antenna reddish-brown; inserted below the middle of face, at the level of the lower orbital borders; scape one and one-third the pedicel; first flagellar slightly more than two and a half times the pedicel; second flagellar three-fourths the first; third equal to second; the rest gradually becoming shorter, except the terminal, which is slightly longer than scape, twice the pedicel and one and one-seventh the penultimate (Fig. 19).

Thorax: slightly shorter than the abdomen, length nearly twice the width; pronotum much reduced; mesonotum two and a half times the scutellum, rugosely sculptured; parapsidal furrows deep and complete; scutellum two-fifths the mesonotum and twice the metathorax; sculpture nearly same as in mesonotum; propodeum one and one-third the scutellum and metathorax combined. reticulately leathery sculptured; propodeal spiracles medium sized and spherical. Legs reddish-brown. Fore femur one and a half times the coxa; tibia four-fifths the femur; tibial spur slightly less than one-third the tibia (Fig. 20). Hind coxa nearly two and three-fourths the trochanter; femur four and three-fourths the trochanter; tibia one and one-seventh the femur; metatarsus three-fifths the tibia and one and a half times the next two tarsi combined; larger tibial spur one and one-fourth the tibia and smaller slightly less than three-fourths the larger. Fore wing length two and a half times the breadth; radius slightly less than one-fourth the length of the wing; basal somewhat longer than half the radius; transversal very slightly less than three-fifths the basal; pterostigma lanceolate; rest of details and hind wing as in Fig. 21 and 22. Abdomen somewhat petiolate, elongate-oval; dorsoventrally compressed, impunctate, with pubescence somewhat longitudinally disposed; eight tergites distinctly visible, first three reddish-brown and larger than the rest, others darker.

Redescribed from 1 male partly dissected on slide No. 25/B and rest on pin, labelled: "C.S.31, from pupa of Dryinidae, Musheri, K.V. Rao Coll. 1-12-1936."

Chlorodryinus pallidus Perkins

1905. *Chlorodryinus pallidus*, PERKINS, *Rep. Expt. Stat. Hawaii, Ent.*, 1 : 57.
1914. *Chlorodryinus pallidus*, KIEFFER, *Das Tierreich*, 41 : 41.
1942. *Chlorodryinus pallidus*, PRUTHI and MANI, *Mem. Indian Mus.*, 13(4) : 425.
1954. *Chlorodryinus pallidus*, KURIAN, *Agra Univ. J. Res.*, 3(1) : 257.

Female.—Length 3.8-4.5 mm. Colour reddish-brown. Head viewed from above length three-fifths the width of the head; interorbital distance half the width of the head; vertex margined, dull and extremely finely sculptured; eyes two and a half times as long as the post-orbital distance, brownish-black, bare, ocelli arranged in an equilateral triangle; interocellar distance equal to front ocellar and both slightly less than half the ocellocular; viewed in front length slightly less than four-fifths the width; interorbital distance half the width of the head; frons and face same sculpture as vertex, with a fine medial longitudinal carina running from between the insertion of antennae right upto the front ocellus; clypeus reddish-brown, with yellowish tinge, slightly convex, apex truncate somewhat bilobed, with white pubescence; mandibles reddish-brown.

Antennae inserted on or very slightly over an imaginary line joining the lower orbital borders; 10-jointed; scape slightly less than twice the pedicel; first flagellar nearly thrice the scape; second three-fifths the first; third four-fifths the second; fourth and succeeding flagellar joints gradually become shorter, terminal somewhat more than the scape and one and a half times the penultimate (Fig. 25).

Thorax: Thrice as long as broad; pronotum somewhat more than one-third the whole of thorax; nearly smooth and shiny; somewhat constricted between pro and mesonotum; mesonotum half the pronotum, roughly irregularly rugoso-sculptured; parapsidal furrows deep and complete; scutellum two-fifths the mesonotum, with a faint rugose sculpture; metathorax three-fifths the scutellum, irregularly rugoso-carinately sculptured; propodeum one-third the whole length of thorax and less than the pronotum, irregularly rugoso-reticulately carinate giving a somewhat leathery appearance; propodeal spiracles large and lanceolate-oval. Legs reddish-brown with yellowish tinge. Fore coxa one and a half times the trochanter; femur nearly two and three-fourths the trochanter; tibia somewhat less than the femur; tibial spur one-seventh the tibia; metatarsus half the tibia and three-fourths the rest of tarsi combined; chela somewhat longer than metatarsus (Fig. 26). Hind coxa three and a half times the trochanter; femur eight times the trochanter; tibia one and one-fifth the femur; tibial spur one-seventh the length of tibia; metatarsus slightly less than two-thirds the femur; half the tibia and slightly more than two-thirds the rest of tarsi combined. (Fig. 27). Fore wing length three and one-fifth the breadth; radius slightly less than one-fifth the length of the wing; basal somewhat more than half the radius; transversal slightly less than half the basal and one-fourth the radius; rest of details and hind wing as in fig. 23 and 24. Abdomen petiolate, petiole black; apically acuminate, three-fourths the thorax; seven tergites distinctly visible; first three much larger than the rest and form nearly two-thirds the whole length of thorax; tergites nearly smooth and shiny; ovipositor sheath distinct; ovipositor exserted; as long as sheath.

Redescribed from a series of females partly dissected on slide and rest on pin labelled, No. 56/B: "Pusa, Bihar, K. Singh, 3-7-1927," No. 28/B: "On sugarcane Pusa, Bihar, B.D. Gupta, 11-12-1930," No. 61/B: "Gurgaon Plantation, G. Ullah Coll. 10-12-1937, On sugarcane," No. 66/B: "Pusa, Bihar, 10-20-1-1928, R.B.C.S. Misra," No. 74/B: "Dryinid parasites on sugarcane, Pusa, Bihar. H.N. Batra, 27-11-1933."

Male.—Length 2.0-2.7 mm. Colour dark reddish-brown to black. Head viewed from above length five eighths the width; interorbital distance very slightly more than half the width of the head; eyes blackish-brown; bare; vertex rugosely sculptured, distinctly margined; ocelli arranged in a broad triangle; interocellar one and one-fifth the ocellocular, which latter is one and two-thirds the front ocellar; viewed in front length two-thirds the width; interorbital distance very slightly less than three-fifths the width of the head; length of eye somewhat more than twice that of gena; frons and face irregularly rugosely sculptured with a leathery appearance in some places; clypeus dark reddish-brown, irregularly rugoso-carinately sculptured, slightly convex, apex rounded; mandibles reddish-brown. Antennae reddish-brown, inserted above the clypeus, below the middle of face and on an imaginary line joining the lower orbital borders; 10-jointed, scape nearly one and one-fourth the pedicel; first flagellar more than twice the scape: second nearly three-fourths the first; third very slightly longer than second; fourth subequal to third; fifth and succeeding joints gradually become shorter; terminal slightly longer than penultimate; one and one-third the scape and one and two-thirds the pedicel (Fig. 30).

Thorax: Length twice the width at the region of tegulae; pronotum half mesonotum; rugosely sculptured; mesonotum roughly irregularly rugosely sculptured, with a few scattered setae; parapsidal furrows distinct and complete; scutellum three-fifths the mesonotum, sculpture nearly same as on the latter; metathorax slightly more than half the scutellum and one-third the mesonotum; sculpture finer than on scutellum; propodeum twice the scutellum, reticulately carinate; propodeal spiracles elongate-oval. Legs light reddish-brown. Fore coxa one and one-third the trochanter; femur somewhat more than twice the trochanter; tibia nearly four-fifths the femur; tibial spur one-third the tibia; metatarsus very slightly more than the tibia and six-sevenths the rest of tarsi combined (Fig. 31). Hind coxa two and two-thirds the trochanter; femur nearly four and a half times the trochanter; tibia one and one-fourth the femur; longer tibial spur one-fourth the tibia and smaller four-fifths the larger; metatarsus somewhat more than half the tibia and less than the rest of tarsi combined (Fig. 32). Fore wing length two and three-fifths the breadth; radius one-tenth the whole length of wing; basal half the radius; transversal somewhat more than half the basal; rest of details and hind wing as in fig. 28 and 29. Abdomen dark reddish-brown; oval; apex pointed; dorsally depressed; seven tergites distinctly visible; tergites smooth and shiny; moderately thickly covered over by short, brown pubescence.

Redescribed from several males partly dissected on slide and rest on pin labelled No. 46/B, 47/B, 49/B, 50/B, 53/B, 75/B: "Pusa, Bihar, 10-20-1-1928, R.B.C.S. Misra."

KEY TO ORIENTAL SPECIES OF *Neodryinus* PERKINS

1. Male, antennae reddish-brown uniformly 2
   Female, antenna not uniformly coloured 4
2. Tegulae pitchy; antennae brown; pterostigma length four times the breadth ... ... *lawanae* Richards
   Tegulae reddish-brown or testaceous; antennae reddish-brown; pterostigma length nearly five times the width 3
3. Ocelli arranged in a broad triangle; tegulae testaceous; mandibles yellowish-brown except reddish-brown tip ... ... *karnalensis*, sp. nov.

Ocelli arranged in a distinctly curved line; tegulae reddish-brown; mandibles brown ... ... *pusaensis*, sp. nov.

4. Mandibles pitchy; smaller whitish spot on each side of the clypeus; tegulae pitchy; wings hyaline ... ... *lawanae* Richards

Mandible whitish-yellow except tip, with a central black spot; tegulae testaceous; wings hyaline with a basal band and one across pterostigma ... ... *leptopus* Richards

Neodryinus karnalensis, sp. nov.

Male.—Length: 2.1-2.8 mm. Colour dark reddish-brown to black. Head viewed from above length half the width of the head; interorbital distance nearly three-fifths the width of the head; width of the eye nearly two and a half times the post orbital distance; vertex narrow, margined, finely and irregularly rugoso-sculptured; with scanty, scattered silvery-white pubescence; ocelli light reddish or yellowish-brown, arranged in a broad triangle; interocellar twice the front ocellar and one and two thirds the ocellocular, which latter is slightly over one and a half times the front ocellar; head viewed in front nearly triangular; length five-sixths the width; interorbital distance somewhat more than half the width of the head; length of eye nearly twice that of gena and somewhat over five times that of the post-orbital; eyes large, brown, pubescent; pubescence short and fine; frons and face roughly rugoso-punctate, with small silvery-white pubescence; clypeus dark reddish-brown, apex lighter, truncate, with a concave cut; mandible yellowish-brown, with brown teeth, apex of teeth being acute and reddish-brown, maxillary palpi, yellowish-brown, 5-jointed; labial palpi short, 3-jointed, same colour; antennal fossa transversely carinate, reaching upto about the middle of face. Antennae reddish-brown, inserted below the middle of face, above the clypeus, on an imaginary line joining the lower orbital borders; 10-segmented; scape nearly equal or may be even very slightly longer than the pedicel; first flagellar two and three-fourths the pedicel; second three-fourths the first; third and succeeding segments gradually become shorter; penultimate slightly more than half the first; terminal nearly one and one-fourth the penultimate, as long as the fifth and one and three-fourths the pedicel (Fig. 35).

Thorax: Black; length twice the width at the region of the tegulae, pronotum two-fifths the whole length of thorax, rugoso-sculptured, with few scattered silvery-white pubescence, mesothorax approximately one-third the whole length of thorax, sculpture nearly same as that of prothorax, with scattered, short, silvery-brown pubescence; parapsidal furrows distinct and complete, somewhat converging posteriorly; tegulae brown; scutellum somewhat less than half the mesonotum, sculpture same as pro and mesothorax but finer, with less pubescence than the former; metathorax half the scutellum, irregularly rugosocarinately sculptured; propodeum nearly as long as mesonotum, reticulately carninately sculptured, with the spaces between the carinae rugosely sculptured; propodeal spiracles fairly large, leniar and lanceolate. Legs reddish-brown, except the dark reddish-brown bases of coxae and light brown tarsi. Fore coxa slightly less than one and a half times the trochanter; femur four and a half times the trochanter; tibia three-fourths the femur; tibial spur somewhat less than half the tibia; metatarsus very slightly longer than tibia and twice the next two tarsi combined (Fig. 38). Hind coxa thrice the trochanter; femur slightly over four times the trochanter and less than the femur; tibial spur two-fifths the tibia: metatarsus more than two-thirds the tibia and somewhat less than the rest of tarsi combined (Fig. 36 & 37). Fore wing hyaline, two and three-fourths the breadth; basal cells bounded by distinct, very often clear veins; radius one-fifth the length of the wing; basal half the radius; transversal four-fifths the basal; pterostigma nearly five times as long as broad; rest of details and hind wing as in fig. 33 and 34. Abdomen dark reddish-brown; nearly four-fifths the thorax, dorso-ventrally flattened, basally bent; seven tergites distinctly visible; first tergite the largest, the rest of them gradually become shorter; tergites smooth and shiny, with somewhat longitudinally arranged rows of short, silvery-white pubescence.

Holotype male, partly dissected on slide No. 72/B and rest on pin, labelled: "C.S.266, from pupa of a Dryinid on sugarcane leaf, Karnal, K. Lakshman coll. 12-10-1937;" *paratype* 1 male partly dissected on slide No. 2/B and rest on pin, labelled: "Reared from sugarcane, N. Ayyar, Pusa collection, Oct.-Nov., 1935

Neodryinus pusaensis, sp. nov.

Male.—Length 1.5 mm. Colour dark reddish-brown to black. Head dark reddish-brown; viewed from above transverse, eyes brown, covered with short pubescence; ocelli reddish-brown, arranged in a distinctly curved line; interocellar distance two and two-thirds the ocellocular, which latter is equal to front ocellar; vertex pubescent; viewed in front length three-fifths the width; interorbital distance half the width of the head; length of eye nearly twice that of gena; post-orbital distance little or nil; clypeus broadly triangular, apex conical; mandibles brown. Antennae reddish-brown uniformly; inserted below the middle of face on an imaginary line joining the lower orbital borders and just above the clypeus; 10-jointed; scape very slightly more than the pedicel; first flagellar slightly less than twice the pedicel; second and third subequal to first; rest of flagellar joints gradually become shorter, penultimate one and one-third the pedicel; terminal one and one-fourth the penultimate and nearly twice the pedicel (Fig. 41).

Thorax: length one and two-thirds the width at the region of tegulae; pronotum one and half times the mesonotum, faintly irregularly sculptured; mesonotum sculpture same as pronotum, but laterally somewhat smooth; parapsidal furrows complete; tegulae reddish-brown; scutellum nearly three-fourths the mesonotum; metanotum shorter, together with the scutellum nearly equal to mesonotum, nearly smooth and shiny; propodeum very slightly longer than mesothorax, scutellum and metanotum combined, roughly irregularly rugoso reticulate; propodeal spiracles medium-sized, elongate-oval. Legs reddish brown with lighter tronchanters. Fore coxa slightly longer than the trochanter; femur nearly two and a half times the trochanter; tibia four-fifths the femur tibial spur slightly less than one-third the tibia; metatarsus slightly less than tibia and one and one-third the next two tarsi combined(Fig. 43). Hind coxa slightly less than two and a half times the trochanter; femur slightly less than four times the trochanter; tibia one and one-third the femur; tibial spur one-fifth the tibia; metatarsus half the tibia and nearly two-thirds the rest of tarsi combined (Fig. 42 & 44). Fore wing hyaline; veins light brown; length slightly less than two and a half times the breadth; radius very slightly more than two-sevenths the length of the wing; basal more than half the radius; transversal slightly less than two-thirds the basal; pterostigma length somewhat less than five times the breadth; rest of details and hind wing as in fig. 39 and 40. Abdomen equal to thorax; seven tergites visible; first and second abdominal tergites slightly longer than the rest.

Holotype one male, No.4/B labelled: "On rice, Pusa, Huq coll. C. No. 2065, 10-8-1930."

Subfamily Gonatopodinae

Pseudogonatopus sogatea Rohwer

1920. *Pseudogonatopus sogatea*, ROHWER, *Proc. U. S. Nat. Mus.*, 57 : 160.
1920. *Pseudogonatopus sogatea*, MISRA, *Mem. Dept. Agric. Ind.*, (*Ent. Ser.*), 5 (5): 207-239.
1942. *Pseudogonatopus sogatea*, PRUTHI and MANI, *Mem. Indian Mus.*, 13 (4): 426-427, fig. 18 and 19.
1954. *Pseudogonatopus sogatea*, KURIAN, *Agra Univ. J. Res.* (*Sci.*), 3(1) : 258-259.
1954. *Pseudogonatopus sogatea*, KURIAN, *Agra Univ. J. Res.* (*Sci.*). 3(2), : 417-422.

This species has recently been fully redescribed by me (*loc. cit.*)

Family BETHYLIDAE

Subfamily Sclerodermínae

KEY TO ORIENTAL SPECIES OF *Cephalonomia* WESTWOOD

1. Scutellum anteriorly with a transverse furrow; antennae brown except scape; legs dark brown, with exception of yellow trochanters, tarsi and fore tibia	*indica* Kieffer
Scutellum with a transverse furrow, broader laterally and much constricted medially with small pits; antennae and legs dark reddish-brown uniformly	*tritici*, sp. nov.
Scutellum without a transverse furrow	*perigrina* Westwood

Cephalonomia tritici, sp. nov.

Male.—Lengh 1.3 mm. Colour dark reddish-brown to black. Head viewed from above length slightly more than half the width; interorbital distance five-sixths the width of the head; width of eye nearly equal to post-orbital distane; vertex finely rugosely sculptured, having a coriaceous appearance, emarginate;

eyes small, blackish-brown, bare; ocelli reddish-brown, small, arranged in a triangle; interocellar distance one-fourth the ocellocular and one and a half times the front ocellar, which latter is one-sixth the ocellocular; viewed in front length slightly more than the width; interorbital distance slightly more than two-thirds the width of the head; eye one and a half times the length of gena, but only about three-fourths the post-orbital distance; frons and face coriaceously leathery sculptured; clypeus reddish-brown, nearly the same sculpture as face, but slightly smoother; mandibles reddish-brown. Antennae dark reddish-brown, except for reddish-brown pedicel and first flagellar; inserted just above the mouth on either side of the clypeus, below an imaginary line joining the lower orbital borders; 12-jointed; scape somewhat club-like, nearly twice the pedicel; first flagellar slightly less than half the pedicel; second flagellar slightly longer than the first; third slightly longer than second, fourth, fifth and sixth subequal (Fig. 46).

Thorax: Length somewhat less than twice the width at the region of the tegulae; pronotum one-third the whole length of thorax; finely rugoso-coriaceously sculptured; mesonotum very short, transverse, one-fourth the prothorax, sculpture same as pronotum; parapsidal furrows absent; scutellum nearly twice the mesonotum, finely rugosely sculptured, giving a faintly shagreened appearance, with two small pits and a transverse furrow anteriorly; metathorax nearly absent; propodeum large, slightly less than half the whole length of thorax, with a shagreened appearance and with a very faint median longitudinal line running up to the transverse carina separating the anterior horizontal area from the posterior slanting part; lateral marginal and basal carina present; propodeal spiracles small and round. Legs dark reddish-brown with lighter tarsi. Fore coxa nearly equal to trochanter, which latter is half the femur; tibia slightly over three-fourths the femur; tibial spur slightly one-third the tibia; metatarsus five-ninths the tibia. Hind coxa slightly over twice the trochanter; femur five times the trochanter; tibial spur slightly less than one-fourth the tibia; metatarsus half the tibia and slightly more than three-fourths the rest of tarsi combined (Fig. 47). Fore wing venation nearly obsolete; length less than thrice the breadth; some indication of a pro and pterostigma which are stigmated (Fig. 45). Abdomen as long as thorax, with a very short, narrow petiole; somewhat flattened dorsoventrally, posteriorly conical; six tergites distinctly visible, first two larger than the rest, second the largest; third onwards tergites gradually become shorter; tergites finely coriaceously sculptured or nearly smooth and shiny, with very few scattered pubescence.

Holotype one male labelled: "from wheat, Pusa, Bihar, 23-11-1935, L. Nigam coll."

KEY TO ORIENTAL SPECIES OF *Scleroderma* LATREILLE

1. Wings vestigial or absent 2
   Wings developed 4
2. Pronotum reddish-brown; antenna yellowish-white; tarsi yellowish-white: ... ... *vigilans* Westwood

Pronotum chestnut-brown or maroon, smooth; head longer than broad; antennae, prothorax, legs and hind margin of three or four posterior tergites straw-yellow ... ... *luteicollis* (Kieffer)

Pronotum testaceous, smooth; head longer than broad; abdomen completely dark reddish-brown; legs and antennae yellowish-brown 3

3. Mandible tridentate ... ... *delhiensis*, sp. nov.

Mandible bidentate ... ... *hardwickiae*, sp. nov.

4. Head reddish-brown; thorax rust red; abdomen dark; mandibles four toothed; ocelli absent ... ... *bicolor* (FredSmith)

Body differently coloured 5

5. Scutellum absent; mandible tridentate; thorax finely leathery sculptured; posterior margin of tergites reddish-brown ... *niger* (Kieffer)

Scutellum present 6

6. Pronotum reddish-brown; tarsi yellowish-white; mesonotum not quite one-third the pronotum; subcosta not interrupted from pterostigma ... ... *vigilans* Westwood

Pronotum reddish-brown; tarsi yellowish-brown, concolouress with tibia; mesonotum nearly half the pronotum; subcosta nearly interrupted from pterostigma, only being indicated by a faint transparent vein ... ... *mori*, sp. nov.

Pronotum darker yellowish; head more chestnut brown; tergites with darker transverse bands ... ... *thwaitesianus* (Westwood)

Scleroderma delhiensis, sp. nov.

Female.—Length 2.0- 2.75 mm. Colour reddish-brown with dark reddish brown to black bands in abdomen. Head reddish-brown, completely prognathous; viewed in front length slightly more than the width; interorbital distance three-fifths the width of the head; length of eye thrice that of gena and two-fifths the postorbital distance; vertex broad, very finely coriaceously sculptured, emarginate, ocelli absent; eyes black, bare; frons and face faintly coriaceously sculptured; clypeus nearly truncate and somewhat excavate; mandible tridentate. Antennae inserted just above the mouth, on the clypeus, below an imaginary line joining the lower orbital borders; reddish-brown, with a golden tinge; 13-jointed; scape length nearly thrice the width, very slightly over two and two-thirds the pedicel; pedicel length nearly one and a half times the width; first flagellar very slightly less than half the pedicel; second and third subequal and are two-thirds the first; rest of flagellar joints gradually become longer, until the penultimate is two-thirds the pedicel and equal to third and fourth joints combined; terminal slightly less than two-thirds the scape, somewhat less than twice the pedicel and slightly less than the three previous flagellar joints combined (Fig. 48).

Thorax: Length thrice the width; mesonotum obscured by pronotum and so invisible from above; pronotum long, somewhat more than one-third the whole length of thorax; testaceous; finely rugoso-coriaceously sculptured, spiracles small and circular; parapsidal furrows absent; scutellum slightly less than two-thirds the pronotum; ferruginous brown, same sculpture as mesonotum, somewhat convex and posteriorly smoothly rounded; scutellar spiracle small and lanceolate; metanotum nearly obsolete, being obscured by scutellum medially and visible only laterally, sculpture and colour same as pronotum, slightly fainter than scutellum; propodeum as long as pronotum; clearly finely rugoso-coriaceously sculptured, without any carina, nearly the same colour as pronotum, propodeal spiracles small and round. Legs reddish-brown. Fore coxa twice the trochanter; femur four times the trochanter, tibia four-fifths the femur; tibial spur one-third the tibia and four-fifths the metatarsus; metatarsus slightly less than half the tibia and nearly three-fourths the rest of tarsi combined (Fig. 49). Hind coxa two and a half times the trochanter; femur three and a half times the trochanter; tibia one and one-fourth the femur; tibial spur two-sevenths the tibia and two-thirds the metatarsus; metatarsus somewhat less than half the tibia and nearly two-thirds the rest of tarsi combined. Wings absent. (Fig. 50 & 51). Abdomen basally somewhat narrowed into a short petiole; ferruginous brown to black, with a golden tinge in the posterior part of each tergite, with few, short, scattered, silvery-brown pubescence; tergites nearly smooth and shiny except for faint rugoso coriaceous sculpture; seven tergites distinctly visible, first the largest; rest of them gradually become shorter, and the last few are nearly sub equal; genitalia somewhat less than half the whole length of abdomen; genital sheath nearly half the last two tergites combined.

Holotype 1 female completely dissected and mounted on slide No. 103/B (a) and paratypes 4, 103/B (b), 101/B, 109/B and 110/B all labelled: "Tentage, Inspection Depot, Delhi Fort, ex: Millet seeds, R.R.D. 49, BCR 121, Cage 678 parasitic on Bostrichidae, dated 15-11-1941, 13-11-1941, 15-11-1941, 12-10-1941, 29-12-1941 respectively."

Scleroderma hardwickiae, sp. nov.

Female.—Length 2.4 mm. Colour reddish-brown, with dark reddish-brown to black abdomen. Head viewed in front nearly rectangular, anteriorly truncate; length somewhat more than the width; interorbital distance four-sevenths the width of the head, eyes small, oval, reddish-brown; bare, placed far anteriorly; ocelli absent; length of eye three and a half times that of gena and half the post-orbital distance; clypeus truncate; mandible yellowish-brown, two toothed; both teeth acute, apices of teeth reddish-brown. Antennae light yellowish-brown; inserted just above the mouth on the clypeus below an imaginary line joining the lower orbital borders; 13-jointed; scape length very slightly less than twice the width; nearly twice the pedicel; pedicel length one and two-thirds the width; first flagellar one-fifth the scape, second three-fourths the first; third and the remaining flagellar joints gradually become longer until the terminal which is nearly two-thirds the scape, one and one-fourth the pedicel and some what less than twice the penultimate (Fig. 52).

Thorax: Length very slightly over thrice the width; pronotum one-third the whole length of thorax; testaceous, very finely sculptured; mesonotum very nearly obliterated; scutellum two-thirds the pronotum; somewhat convex; metanotum very short or practically obsolete; propedeum somewhat longer than pronotum and about twice the scutellum, nearly smooth and shiny; with a slight constriction in the anterior one-sixth, posteriorly abruptly narrowed; propodeal spiracles small and round. Fore coxa two and a half times the trochanter; femur very slightly over four times the trochanter. Abdomen dark reddish-brown except for golden brown bands at the posterior end of each tergite; petiolate, petiole very short, one-sixteenth the whole length of abdomen; six tergites distinctly visible, second tergite the largest, rest of them gradually become shorter except the last, which is one and a half times the penultimate tergite; ovipositor sheath distinct.

Holotype Female, wholly dissected and mounted on slide No. 111/B labelled; "Timberyard, Madras, C.F.C. Beeson, S.F.B. 1460, RRD 490 BCR 136, Cage 606, ex: *Hardwickia pinnata*, parasitic on Lycidae, 13-10-1941."

Scleroderma mori, sp. nov.

Male.— Length 2.5 mm. Colour reddish-brown, with dark reddish-brown to black abdomen. Head reddish-brown; completely prognathous; viewed in front length one and one-eighth the width; interorbital distance nearly three-fifths the width of the head; length of eye nearly four times that of gena; post-orbital distance one and two-thirds the length of eye; eyes small and black; vertex smooth and shiny, broad, nearly emarginate; ocelli yellowish-brown; interocellar distance five-sixths the front ocellar and one-sixth the ocellocular which latter is five times the front ocellar; frons and face smooth and shiny; clypeus truncate, with a carina medially running as a black line upto a level of about half the length of eye; mandible reddish-brown, with darker teeth; antennae inserted below the middle of face, just above the clypeus, 13-jointed; scape length nearly two and one-fourth the width, two and one-fourth the pedicel; pedicel length twice the width; first flagellar one-third the pedicel, second and third sub-equal and nearly two-thirds the first; fourth equal to first; fifth and following segments very gradually become longer, until the penultimate is half the pedicel; terminal half the scape, one and one-seventh the pedicel and somewhat longer than the previous two flagellar joints combined (Fig. 56 & 57).

Thorax: reddish-brown, darker in a few places, length thrice the width at the region of the tegulae; pronotum light reddish-brown, one-third the whole length of thorax; finely rugoso-coriaceously sculptured; anteriorly depressed and narrowed into a sort of neck, slightly overlapping the mesonotum posteriorly; mesonotum dark reddish-brown, half the pronotum, same sculpture as the latter; parapsidal furrows incomplete, found in the posterior one-third only; scutellum slightly shorter than mesonotum, same colour as the latter, medially same colour as mesonotum, but laterally lighter, same sculpture as pro and mesonotum; metathorax very short; somewhat smoother than rest of thorax; propodeum slightly longer than pronotum, one and one-sixth the mesonotum, scutellum and metanotum combined, darker medially in the anterior half, rest of propodeum having the same colour as pronotum; very distinctly rugoso-coriaceously sculptured anteriorly and somewhat smooth and shiny in the rest, smoothly declivous posteriorly; lateral marginal and basal carina absent. Legs yellowish-brown, except lighter tarsi. Fore coxa twice the trochanter; femur nearly four times the trochanter; tibia five-sixths the femur; metatarsus somewhat less than half the tibia and nearly two-third the rest of tarsi combined; tibial spur nearly one-third the tibia and three-fourths the metatarsus (Fig. 55). Hind coxa two and a half times the trochanter; femur nearly four times the trochanter; tibia one and one-sixth the femur and slightly over twice the metatarsus; larger tibial spur nearly one-fourth the tibia, smaller three-fifths the larger; metatarsus twice the larger spur, and three-fifths the rest of tarsi combined (Fig. 58). Fore wing length very slightly over three and one-third the breadth; veins yellowish-brown; radial absent; basal short, nearly as long as distal abscissa of subcosta; transversal two and one-third the basal, much longer than the distal abscissa of subcosta and nearly reaching the much slender anal vein; rest of details and hind wing as in fig. 53 and 54. Abdomen slightly longer than thorax; dark reddish-brown, with metallic green, red and golden tinge, basally somewhat constricted into a very short and obscure petiole; 7 tergites distinctly visible; tergites nearly smooth and shiny, with few short golden-brown pubescence, irregularly scattered; second tergite the largest and twice the rest; rest of them subequal except the last which is very short; male genitalia very short, as long as the last tergite.

Holotype 1 male, partly dissected and mounted on slide and rest on pin labelled; "Makum, Lakhimpur, Assam, R.R.D. 981, BCR 88, Cage 809, ex: *Morus laevigata*, emerged along with *Pilinus binodulus* Motschulsky (Fam. Anobiidae), C.F.C. Beeson coll., 24-12-1941."

Laelius agraensis, sp. nov.

Female.— Length 3 mm. Colour: black, head viewed from above slightly less than two-thirds the width; interorbital distance slightly more than two-thirds the width of the head; postorbital slightly more than the width of eye; eyes brown, bare, ocelli very dark brown; interocellar distance slightly more than half the ocellocular which latter is two and three-fifths the front ocellar; vertex rugosely sculptured; broad and rounded, emarginate; viewed in front length slightly more than the width; interorbital distance two-thirds the width of the head; length of eye nearly one and a half times that of gena and equal to the post-orbital distance; frons and face finely rugosely sculptured, giving a shagreened appearance; clypeus truncate with a median longitudinal carina, which continue upwards in the face as a faint line upto a level of about one-third the length of eye; mandibles reddish-brown. Antennae reddish-brown, with slightly lighter scape, pedicel and first flagellar, inserted far below the middle of face, below an imaginary line joining the lower orbital borders, just above the clypeus; 13-jointed; scape slightly more than one and a half times the pedicel; first flagellar joint nearly three-fourths the pedicel, second slightly smaller; rest of joints gradually become smaller; terminal joint slightly more than half the scape; a little less than the pedicel and one and three-fourths the penultimate (Fig. 61).

Thorax: Length two and a half times the width at the region of the tegulae; prothorax one-third the whole length of thorax; irregularly rugoso-coriaceously sculptured in some parts and smooth and shiny in other places; mesothorax slightly over two-thirds the prothorax, faintly rugoso-coriaceously sculptured, parapsidal furrows absent; scutellum half the mesonotum, medially rugosely sculptured and the rest being nearly smooth and shiny; metathorax one-fourth the scutellum, smooth and dull; propodeum somewhat less than half the thorax; reticulately carinately sculptured, there is a median longitudinal carina and three pairs of lateral carinae, three on each side; the inner most one is complete, the carinae just outer to these are incomplete posteriorly, whereas the outermost lateral carinae are somewhat incomplete anteriorly; only the median longitudinal carina runs up to the posterior end of propodeum; the rest of those that are complete stop at the transverse carina which separates the anterior horizontal area from the posterior slanting part; lateral marginal and basal carina present. Legs reddish-brown, except dark reddish-brown coxae, beset with spinous setae especially at the apices of tarsi; coxae twice the trochanters, femur slightly over twice the coxa; tibia six-sevenths the femur; tibial spur somewhat smaller than one-fourth the tibia; metatarsus half the tibia and nearly five-sixths the rest of tarsi combined (Fig. 64). Hind coxa two and a half times the trochanter; femur slightly less than twice the coxa; tibia one and one-sixth the femur; larger tibial spur one-fifth the tibia, smaller slightly longer than half the larger; metatarsus slightly less than half the tibia; rest of tarsi one and two-thirds the metatarsus; claw simple, with two or three stiff setae arising from base (Fig. 62 & 63). Fore wing length very slightly more than two and a half times the breadth; apical two-thirds light brown, basal one-third hyaline; pterostigma and veins light brown and are beset with few long, black, bristles; costa and subcosta fused; pterostigma small, length twice the breadth; radius short, nearly three-fourths the basal and somewhat longer than the transversal; rest of details and hind wing as in fig. 59 and 60. Abdomen one and one-fourth the thorax; dorsally arched, apically acuminate; black, apically somewhat reddish-brown; 7 tergites distinctly visible; second the largest; rest of them subequal, except the penultimate, which being the shortest; tergites faintly coriaceously sculptured, with few long scattered setae; ovipositor exserted and as long as the last tergite.

Holotype 1 female, partly dissected and mounted on slide No. 10/B and rest spirit labelled: "On wing, St. John's College, Agra, coll. Chandy Kurian, 13-9-in 1949."

This species approaches the only other known Indian species *Laelius voracis* Muesebeck, but is readily distinguished by dark brown ocelli; interocellar being slightly more than half the ocellocular; front ocellar slightly more than one-third the ocellocular and propodeum with seven longitudinal carinae, other than the lateral marginal carinae.

Laelius voracis Muesebeck

1939. *Laelius voracis*, MUESEBECK, *Biol. Soc. Washington Proc.*, 52 : 172.
1940. *Laelius voracis*, MUESEBECK, *Proc. ent. Soc. Washington*, 42 : 110.
1951. *Laelius voracis*, MUESEBECK and WALKLEY, *U. S. Dept. Agric.* (*Agric. Mon.*), 2: 728.
1954. *Laelius voracis*, KURIAN, *Agra Univ. J. Res.* (*Sci.*), 3(1) : 265.
1954. *Laelius voracis*, KURIAN, *Agra Univ. J. Res.* (*Sci.*), 3(2) : 422-423.

This species has recently been fully redescribed by me (*loc. cit.*) It has been recorded for the first time from India.

Subfamily Mesitinae

KEY TO ORIENTAL SPECIES OF *Mesitius* SPINOLA

1.	Pronotum with a distinct median longitudinal furrow, each lateral area of mesonotum traversed by a longitudinal groove ...	2
	Pronotum at the most with a trace of median furrow; lateral areas of mesonotum without a groove	*indicus* Kieffer
2.	Terminal three abdominal segments red	*haemorrhoidalis* (Magretti)
	Abdomen black, except extreme apex which in a few cases are dark reddish-brown or dull red	3
3.	Second tergite strongly punctate	4
	Second tergite finely punctate or nearly smooth and shiny ...	5
4.	Antennal segments 4-13 twice as long as wide	*luzonicus* Kieffer
	Antennal segments 4-13 more than twice as long as wide ...	*philippinensis* Kieffer
5.	Pronotum very roughly sculptured, lateral anterior angles of pronotum projecting slightly; antennae and legs brownish ...	*punctaticollis* Fouts
	Pronotum fairly smooth, lateral anterior angles of pronotum not projecting; antennae brownish to piceous or rufous ...	6
	Pronotum roughly rugosely sculptured, posterio-laterally expanded and projecting as two blunt teeth; antennae dark reddish-brown	7
6.	Legs dark brown	*orientalis* Fouts
	Legs nearly rufous	*bakeri* Fouts
7.	Head viewed in front length slightly more than the width; scape two and two-thirds the pedicel; terminal joint very slightly less than the pedicel	*bahaduri*, sp. nov.
	Head viewed in front length slightly less than the width; scape two and a half times the pedicel; terminal joint only three-fourths the pedicel	*duni*, sp. nov.

Mesitius bahaduri, sp. nov.

Female.—Length 5.2 mm. Colour black, with apex of abdomen reddish-brown. Head black, nearly prognathous; viewed from above length half the width; interorbital distance four-sevenths the width of the head; post-orbital slightly less than the width of eye; eyes dark brown; with few scattered, somewhat long, silvery-white pubescence; ocelli golden-yellowish-brown; arranged in a nearly equilateral triangle; in the space between the ocelli, the sculpture is almost the same as the rest, but punctae are comparatively smaller; interocellar space one and one-fifth the front ocellar, very slightly less than two-thirds the ocellocular, which latter is slightly less than twice the front ocellar; vertex roughly irregularly rugosely sculptured, with large, silvery-white pubescence, punctae large, posteriorly distinctly margined; viewed in front length slightly more than the width; interorbital distance somewhat more than half the width of the head; postorbital distance slightly less than half the length of eye, which latter is very slightly more than one and a half times that of gena; frons and face sculpture nearly the same as that of vertex, with fairly long, silvery-white pubescence; clypeus and mandibles reddish-brown, former somewhat prominent, with apex nearly rounded, with a median longitudinal carina running up to the base of insertion of antennae and then continuing up on the frons and face as a depressed line up to the front ocellus; mandibles strong, first tooth acute, rest blunt. Antennae dark reddish-brown, inserted below the middle of face, far below an imaginary line joining the lower orbital borders, just at the base of the clypeus on either side; scape two and two-thirds the pedicel; first flagellar slightly longer than the pedicel; second somewhat less than two-thirds the first; third and succeeding joints subequal or after very slightly increasing, then decrease in size, except the terminal which is one and two-thirds the penultimate, one-third the scape, slightly less than the pedicel and slightly more than three-fourths the first flagellar (Fig. 67).

Thorax black, one and six-sevenths the width at the region of the tegulae; prothorax approximately one-third the whole length of thorax, roughly sculptured with few broad punctae and irregularly scattered silvery-brown pubescence; medial longitudinal depression very distinct; mesothorax half the prothorax, with few indistinct, scattered small punctae; tegulae dark reddish-brown; parapsidal furrows distinct, deep and posteriorly broadened into somewhat like foveae, which nearly reach the posterior margin; scutellum nearly flat, as long as mesothorax, somewhat finely but irregularly rugosely sculptured, with few broad punctae as on prothorax; metathorax one-fourth the scutellum, nearly smooth and shiny, medially depressed, laterally elevated; propodeum one and one-fifth the scutellum and metathorax combined; reticulately carinate, with a definite pattern; propodeum separated from metathorax by a carina, from which are given off five carinae, one median longitudinal and four lateral, two on either side of median; inner ones somewhat converging and outer nearly parallel to the median; all longitudinal carinae meet the transverse carina that separates the anterior horizontal area from the posterior slanting part; the place where the outer longitudinal carina meet the transverse carina posterio-laterally are given off two spinous processes one on each side; lateral and basal carina are also present; the posterior area of propodeum is nearly perpendicularly declivous, roughly rugosely sculptured and with a median longitudinal carina; propodeal spiracles large, lanceolate and somewhat crescent-shaped. Legs dark reddish-brown, with lighter tarsi. Fore coxa twice the trochanter, femur nearly four times the trochanter; tibia three-fourths the femur; tibial spur half the tibia and three-fourths the metatarsus; metatarsus two-thirds the tibia and one and one-fourth the next three tarsi combined (Fig. 69). Hind coxa slightly less than two and a half times the trochanter; femur four and three-fourths the trochanter; tibia slightly longer than femur; larger tibial spurs one-fifth the tibia and smaller three-fourths the larger; metatarsus half the tibia and one and one-fourth the next two tarsi combined; claw bifid (Fig. 68). Fore wing brown with two hyaline areas one at extreme base and the other about the middle below the pterostigma; length two and four-sevenths the breadth, veins reddish-brown, pterostigma lighter; costa and subcosta nearly fused; radial smoothly curved, arising from apex of pterostigma, two-seventh the length of the wing; basal very slightly over one-fourth the radial and five-sixths the transversal; transversal branched, anterior branch somewhat vague; rest of the wing venation, pubescence and hind wing as in fig. 65 and 66. Abdomen as long as thorax; bent basally, somewhat arched dorsally; black, with a reddish-brown apex; five tergites distinctly visible; first tergite the largest, two-fifths the whole length of abdomen; second slightly smaller; the rest of them subequal and much shorter than the first two; tergites smooth and shiny, with few scattered, silvery-brown setae; ovipositor sheath half of the last tergite and dark reddish-brown; ovipositor as long as the ovipositor sheath, reddish-brown.

Holotype 1 female, partly dissected on slide No. 96/B and rest on pin labelled: "Pusa, Bihar, U. Bahadur, 28-7-1915."

Mesitius duni, sp. nov.

Male.—Length 5.5 mm. Colour black, with apex of abdomen reddish-brown. Head viewed from above length two-thirds the width of the head; interorbital distance slightly less than two-thirds the width of the head; post-orbital distance equal to width of eye; eyes brownish-black, with few scattered setae; ocelli arranged in a triangle; yellowish-brown; interocellar distance one and one fourth the front ocellar and two-thirds the ocellocular, which latter is slightly less than twice the front ocellar; vertex roughly and irregularly rugosely sculptured, punctae coalescing in the posterior margin, with few scattered silvery-white pubescence, pubescence more laterally; distinctly morgined; viewed in front length somewhat more than the width; interorbital distance somewhat less than two thirds the width of the head; length of eye one and four fifths that of gena and one and one-third the post-orbital; frons and face very distinctly rugoso-punctate; punctae large, with few, short, scattered pubescence; clypeus reddish-brown, apex nearly rounded, with few long silvery-brown setae, a highly raised median carina runs up to the base of insertion of the antennae, lateral to which are depressions which are coriaceously sculptured; mandibles reddish-brown, with four teeth; teeth darker than base of mandible, all the teeth blunt. Antennae dark reddish-brown; inserted just above the clypeus, far below the middle of face, much below an imaginary line joining the lower orbital borders; 13-jointed; scape two and a half times the pedicel; first flagellar slightly longer than pedicel; second four-sevenths the first; third to seventh equal to second; eighth to tenth slightly shorter than the previous segments and are subequal; terminal one and two-thirds the penultimate, three-fourths the pedicel and slightly less than one-third the scape. (Fig. 70).

Thorax: Length twice the width at the region of the tegulae; pronotum nearly one-fourth the whole length of thorax, roughly rugoso-punctate, nearly the same sculpture as vertex, with a median longitudinal fovea, few short and scattered pubescence, posteriolaterally expanded and projecting as two blunt teeth, anteriorly gradually narrowed; mesothorax as long as prothorax, with a few shallow irregular punctae and very short pubescence; parapsidal furrows deep and complete, posteriorly somewhat converging; lateral furrow present; median longitudinal fovea very distinct; scutellum nearly three-fourths the mesothorax, with few irregular large punctae and a posterior median carina, with two large deep fovae anterio-laterally; propodeum slightly over one-third the whole length of thorax; lateral marginal and basal carina present, as also the transverse carina separating the anterior horizontal area from the posterior slanting part; a median longitudinal carina run the whole length of propodeum, as also two pairs of lateral carinae, two on either side of the median, running down and joining the transverse carina; interconnecting these longitudinal carinae are transverse carinae, forming a reticulate carination and giving the whole horizontal area of propodeum a multifoveate appearance; the posterior part of propodeum is roughly rugoso-reticulate, with a leathery appearance; posterior angles of propodeum projecting coarsely like a tooth. Legs reddish-brown, except dark reddish-brown coxae, trochanter and femur. Fore coxa length one and six-sevenths that of the trochanter; femur slightly over three and a half times the trochanter; tibia three-fourths the femur; tibial spur slightly less than half the tibia; metatarsus nearly two-thirds the tibia and somewhat shorter than the rest of tarsi combined (Fig. 71). Hind coxa slightly over twice the trochanter; femur four and one-third the trochanter; tibia one and one-eighth the femur; larger tibial spur one-fifth the tibia and smaller two-thirds the larger; metatarsus slightly less than half the tibia and three-fourths the rest of tarsi combined; whole leg especially apices of tarsi beset with spinous setae; claw bifid (Fig. 74 & 75). Fore wing brown with clear bands one at extreme base and the other about the middle, below the pterostigma, length two and two-third the breadth; costa and subcosta fused, reddish-brown, rest of veins light brown, pterostigma lighter; radial arising from the apex of pterostigma, smoothly curved up; three-tenths the length of the wing; basal slightly longer than one-fourth the radial, with a vague anterior branch arising from above the middle; rest of details and hind wing as in fig. 72 and 73. Abdomen black; as long as thorax; dorsally arched; apex reddish-brown, apices of anterior tergites also with a reddish-brown hue; six tergites distinctly visible, first few much longer than the rest, second the largest; tergites nearly smooth and shiny, except third which is coriaceously sculptured.

Holotype 1 male, completely dissected on slide No. 122/B labelled: "For Zool. Coll., Shisham bark, Dehra Dun, 22-1-1913."

Lustrina, gen. nov.

Metallic coloured specimens with a variety of lustre from violet to red, with very marked rough sculpture and profusely pubescent. Eyes bare; ocelli large; inner orbital borders converge posteriorly; face rugoso-punctate, with long, scattered, stiff setae; clypeus slightly raised in the form of a lip; antennae inserted above the clypeus, 13-jointed. Thorax length twice the width; pronotum without a median longitudinal line; mesonotum with deep, distinct and complete parapsidal furrows; lateral furrows complete; propodeum roughly rugosocarinately sculptured. Legs reddish-brown, with stiff sinous setae; femora slightly swollen in both the fore and hind legs; claw bifid. Wings brown, with a transverse hyaline band medially more to the basal side and another clearer area to the apex; post-marginal absent; radius arising from nearer the distal end of somewhat lanceolate pterostigma. Abdomen elongate-oval, dorsally somewhat arched, apex conical. Genotype *Lustrina assamensis*, sp. nov.

This genus runs to *Godfrinia* Kieffer in couplet No. 40 in Kieffer's key to genara of Bethylidae,[1] but is easily distinguished by the eyes being bare, pronotum without a median longitudinal impression; scutellum in front without impression; propodeum not distinctly margined behind.

Lustrina assamensis, sp. nov.

Female.— Length 6.5 mm. Colour metallic multicoloured. Head brown with a violet lustre, densely pubescent; length somewhat more than half the width; interorbital half the width of the head; width of eye four times the post-orbital distance; vertex distinctly rugosely sculptured; ocelli large, reddish-brown, arranged in a triangle; interocellar five-sevenths the ocellocular which latter is one and three-fourths the front ocellar; viewed in front length seven-eighths the width; interorbital distance half the width of the head; eyes brownish black, bare; length of eye three and two-thirds the gena; inner orbital border converge posteriorly: face rugoso-punctate, with few long, scattered, stiff, reddish-brown setae; above the clypeus starts a depression between the insertion of antennae and proceeding vertically upto front ocellus; clypeus dark reddish-brown, apex nearly truncate, slightly raised in the form of a lip, mandible dark reddish-brown, slender and apically bidentate, first tooth acute, second somewhat blunt; maxillary palpi 5-jointed, dark reddish-brown, apex of third joint slightly swollen; Antennae dark reddish-brown; inserted above the clypeus, below an imaginary line joining the lower orbital borders; 13-jointed; scape nearly thrice the pedicel; first flagellar slightly more than one and a half times the pedicel; second flagellar two-fifths the first; third to tenth subequal and nearly equal to the second; terminal one and one-third the penultimate, slightly less than one-third the scape and six-sevenths the pedicel; rest of details as in fig. 79.

Thorax brown, with a reddish-metallic lustre, except in propodeum where it is metallic blue in some places and green elsewhere; length twice the width; prothorax somewhat less than one-fourth the whole length of thorax, roughly irregularly, rugosely sculptured, with a few long brown setae; mesothorax one and one-fourth the prothorax, sculpture same as in the prothorax; parapsidal furrows deep, distinct and complete; scutellum slightly more than half the mesonotum, sculpture same as the mesonotum; metathorax two-thirds the scutellum, sculpture almost the same except that the punctae are small and there is a golden tinge; propodeum slightly more than metathorax and scutellum combined; roughly reticulocarinately sculptured, with a definite pattern for the sculpture, which is symmetrical on either side; many branching irregular longitudinal carinae can be distinguished traversing the anterior horizontal area of propodeum, which joins the nearly zigzag transverse carina, which separates the anterior horizontal area from the posterior slanting part and which laterally ends in two teeth, one on either side, directed posteriorly; in the slanting part of propodeum can be noticed a median longitudinal carina and laterally a few other irregular carinae; lateral marginal and basal carina present; propodeal spiracles lanceolate, placed in deep foveae. Legs reddish-brown, with stiff spinous setae; fore coxa twice the trochanter; femur more than twice the trochanter and more than one a half times the coxa; tibia slightly less than five-sixths the femur; tibial spur slightly more than one-third the tibia; metatarsus slightly less than three-fourths the tibia and six-sevenths the rest of tarsi combined (Fig. 80). Hind coxa two and one-fourth the trochanter; femur nearly four and a half times the trochanter; tibia one and one-seventh the femur; tibial spur slightly less than one-fourth the tibia; metatarsus five-ninths the tibia and five-sixths the rest of tarsi combined; claw bifid. (Fig. 78). Fore wing brown with a transverse hyaline band medially more to the basal side; length two and two-thirds the breadth; radius somewhat less than one-sixth the length of the wing; basal same length as the radius; transversal somewhat more than one-third the basal; subcosta and costa distinct and separate, three closed basal cells; hind wing basal half hyaline, apical half brown, with five frenular hooks; rest of details and venation as in fig. 76 and 77. Abdomen length nearly equal to thorax; dorsally somewhat arched, petiolate, petiole very short; four tergites distinctly visible; first tergite subequal to second, which latter is five-sevenths the third, which is the largest; fourth four-sevenths the third; tergites with a variety of lustre; first is mostly green; second violet third blue, green and violet, with a golden-yellow band anteriorly, fourth basally yellowish-brown, apically black; tergites profusely covered over by silvery-white pubescence; first nearly smooth and shiny; second distinctly roughly punctate; third and fourth tergites punctation more marked and rough; ovipositor-sheath half the fourth visible tergite, reddish-brown; ovipositor not exserted.

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[1] KIEFFER. 1914. *Das Tierreich*, 41 : 228.

Holotype female, partly dissected on slide No. 48/B and rest on pin labelled: "H. Inglis coll., Murphulani, T.E. Assam, 1-12-1920."

Subfamily Epyrinae

KEY TO ORIENTAL SPECIES OF *Epyris* WESTWOOD

Median segment with 1 longitudinal carina in the middle; grooves of scutellum separated from one another by at least their breadth	2
Median segment with three longitudinal carinae in the middle ...	4

Median segment with five longitudinal carinae in the middle ... 19

2. Parapsidal furrows converging behind 3

Parapsidal furrows parallel ... ... *ruficornis* (Magretti)

3. Post-marginal wanting ... ... *parvidens* Kieffer

Post-marginal well developed ... ... *unicarina* Kieffer

4. Pronotum with an impressed crossline in front and behind ... *quaesitor* Kieffer

Pronotum without an impressed crossline in front and behind ... 5

5. Eyes glabrous; third antennal joint of male longer than fourth, second thinner than third 6

Eyes hairy 7

6. Metapleura coarsely longitudinally striate; pterostigma and radial black-brown ... ... *psilomma* Kieffer

Metapleura leathery sculptured, with a few large irregularly scattered punctae; peterostigma and radius reddish-brown, rest of veins light brown ... ... *delhiensis*, sp. nov.

Metapleura finely coriaceous; pterostigma and all veins golden-yellow ... ... *quadratus* Kieffer

Metapleura coarsely sculptured; pterostigma and all veins light brown ... ... *manii*, sp. nov.

7. Grooves of scutellum separated from one another by at least their breadth 8

Grooves of scutellum in contact or separated only by a carina ... 11

8. Costal wanting; grooves of scutellum separated by twice their breadth ... ... *apertus* Kieffer

Costal present 9

9. Head almost twice as long as broad; eyes shorter than occiput; veins and pterostigma yellow ... ... *magniceps* Kieffer

Head length one and one-sixth the breadth; eyes longer than occiput; veins and pterostigma light brown ... *patnae*, sp. nov.

Head almost circular; eyes atleast as long as broad ... 10

Head length one and one-third the breadth; with a small blunt carina between antennae ... ... *albopilosus* Cameron

10. Eyes more than twice as long as occiput; grooves of scutellum separated by their diameter; veins and pterostigma yellow ... *pusillus* Kieffer

Eyes as long as occiput or scarcely longer, grooves of scutellum separated by three times their diameter; pterostigma blackish-brown veins pale ... ... *distans* Kieffer

11. Transversal branching off before the middle in a short branch ... *subramosus* Kieffer

Transversal without branch 12

12. Eyes distinctly longer than occiput 13

Eyes only as long as occiput; head coarsely and closely punctured; propodeum atleast as long as broad; post-marginal wanting... *obliquus* Kieffer

Eyes as long as occiput; head finely leathery; radius thrice as long as post-marginal ... ... *niger* Westwood

13. Post-marginal well developed; wings hyaline ... 14

Postmarginal wanting 15

14. Legs yellow, middle of femora brown; pterostigma and veins brown; pronotum and mesonotum opaque, finely coriaceous, unpunctured *claripennis* Kieffer

Legs black, tibiae and tarsi red; pterostigma and veins yellow; pronotum coriaceous and closely punctate; mesonotum smooth and shiny ... ... *despectus* Kieffer

15. Legs uniformly coloured reddish-yellow; eyes two-thirds longer than occiput; propodeum atleast as long as broad; pronotum and mesonotum smooth and shiny ... *rejectus* Kieffer

Legs partly black; eyes not so long; propodeum somewhat transverse 16

16. Mesonotum smooth and shiny in the anterior half, in the posterior coarsely and closely punctured like the pronotum; coxae and femora black 17

Mesonotum uniformly sculptured 18

17. Mandible bidentate; wing hyaline; antennae reddish-brown ... *bidens* Kieffer

Mandible tri-dentate ... ... *tridens* Kieffer

18. Pronotum, mesonotum and scutellum shallowly and not very coarsely punctured; grooves of scutellum separated by a carina ... *philippinensis* Kieffer

Pronotum and mesonotum opaque, finely coriaceous, unpunctured; scutellum smooth and shiny ... *troglodytes* Kieffer

19. Legs dark red, coxae black; antenna dark red; frons with an impressed line ... ... *striatus* Kieffer

Legs including coxae dark reddish-brown, except for lighter tibiae and tarsi; antennae reddish-brown; frons without an impressed line ... ... *agrensis*, sp. nov.

Legs and antennae of different colour; frons with or without an impressed line 20

20. Length of eye as long as post-orbital distance; wings hyaline ... *ruficollis* Ashmead

Length of eye distinctly more than the post-orbital; wings generally subhyaline, yellowish or clouded or slightly yellowish ... 21

21. Mesonotum nearly half the pronotum; wings subhyaline, clouded or slightly yellowish 22

Mesonotum only one-third the pronotum; wings yellowish ... 23

22. Wings subhyaline 24

Wings yellowish or slightly clouded 25

23. Middle tibiae closely spined; legs and antennae yellowish-red; mandibles yellowish-red, multidentate; pronotum thrice mesonotum radial twice basal ... ... *valens* Kieffer

Middle tibiae unarmed; legs brown, knees and tarsi red; antennae brown; mandibles red; pronotum more than thrice mesonotum; radial thrice basal ... ... *feai* Kieffer

Middle tibiae sparsely spined; legs and antennae dark reddish-brown; mandibles reddish-brown; pronotum three and a half times mesonotum; radial two and three-fourths the basal ... *duttai*, sp. nov.

24. Pronotum somewhat coarsely punctate; head almost with fine white pubescence; quadrate, shiny, closely and coarsely punctate ... *laticrus* Kieffer

Pronotum delicately coriaceous; head nearly round, smooth and polished, but with numerous minute setiferous punctures ... *politiceps* Muesebeck

25. Head nearly shiny, with very fine leathery sculpture, coarsely and closely punctate; pronotum leathery; mesonotum half pronotum ... ... *secondus* Brues

Head delicately coriaceous, with numerous but well separated distinct punctae; pronotum sculpture like head except that punctation is widely spaced medially; mesonotum not more than half as long as pronotum ... ... *coriaceous* Muesebeck

Epyris agrensis, sp. nov.

Female.—Length 5.5 mm—6.0 mm. Colour dark reddish-brown to black. Head nearly hypognathous; viewed in front nearly flattened, frons and face coriaceously sculptured, with distinct but shallow and scattered punctae and fairly long golden yellow pubescence; length equal to width; vertex margined; occiput transversely coriaceously striate; ocelli distinct; faintly yellowish-white; interocellar distance slightly more than one-fourth the ocellocular; one and one-fourth the front ocellar and one and three-fourths its own diameter; eyes dark greyish-brown, bare, somewhat small; clypeus prominent, bipronged, reddish-brown; with antennae arising from above the processes; mandible same colour as antennae, darker towards the apex; five toothed, first acute, rest nearly blunt; pubescent; pubescence same as on antennae. Antenna 13-jointed; reddish brown, covered with silvery-white pubescence; scape long, twice as long as thick; pedicel one-third the scape, very narrow compared to scape; first flagellar equal to pedicel; rest of flagellar joints subequal and slightly longer than the first; terminal joint slighly less than twice the first (Fig. 81).

Thorax reddish-brown to black; faintly rugosely reticulate; pronotum long, nearly the same length or slightly shorter than propodeum, narrower in front, with distinct scattered punctae and golden yellow pubescence; propleura with diagonal grooves, which are longitudinally rugoso-striate and with a metallic green lustre; mesonotum short, sculpture and pubescence same as on pronotum, with distinct parapsidal furrows; lateral furrows distinct but incomplete; metathorax slightly coarser sculptured, with two distinct foveae on either side; propodeum long with posterior one-third slanting, anterior two-thirds with five longitudinal carinae, which are interconnected by transverse carinae; outer lateral carinae posteriorly converge, inner parallel; propodeal spiracles anteriorly, laterally placed, spiracular foveae smooth and shiny, laterally carinate; anterior and posterior areas demarcated by a carina, former faintly rugosely striate, striations transverse, posterior end of anterior area with many sulci, posterior area coarsely transversely striate; median longitudinal carina runs down the whole length of propodeum. Legs reddish-brown, with lighter tibiae and tarsi. Fore leg thick set; femur much swollen, four one-fourth trochanter, tibia slightly over two-thirds the femur; much narrower; metatarsus slightly less than half the tibia and two-thirds rest of tarsi combined; tibial spur somewhat less than half the tibia and slightly less than the metatarsus; claw bifid (Fig. 85). Hind coxa slightly less than twice the trochanter; femur three and one-third the trochanter; tibia one and one-eighth the femur; metatarsus slightly less than half the tibia and half the rest of tarsi combined; larger tibial spur slightly less than one-third the tibia and a little longer than three-fifths the metatarsus; smaller spur nearly half the larger; claw bifid (Fig. 84). Wings hyaline, except for very faintly dusky area anteriorly in the fore wing; fore wing length two and a half times the breadth; pterostigma length two and half times the breadth, with a very clear area at basal end and also another between apex of pterostigma and the short punctiform postmarginal, which latter is slightly less than one-fourth the pterostigma; basal joins the subcosta almost at the place where it joins pterostigma; costa and subcosta not coalescing for major part of their length, thus enclosing a narrow cell; radius arising from nearly the middle of pterostigma, smoothly arched, somewhat less than thrice the pterostigma and about two-sevenths the length of the wing; basal somewhat more than one-third the radial and very slightly longer than transversal, apex of which is clear; hind wing with four frenular hooks (Fig. 82 & 83). Abdomen basally black, apically reddish-brown, apex acuminate, petiolate, petiole short; seven tergites distinctly visible; first two nearly smooth and shiny except basal area of second tergite which is faintly transversely coriaceously sculptured; tergites third to seventh finely rugosely punctate, with short silvery-brown pubescence, which are more profuse, long and erect laterally and apically; second tergite the largest and is one and three-fourths the first; third tergite one and one-fourth the first; fourth to six equal to first; seventh half the sixth; ovipositor reddish-brown, twice as long as the last tergite.

Holotype female partly dissected on slide No. 20/B and rest on pin, paratypes 4 female on pin labelled: "On wing, St. John's College, Agra, coll. Chandy Kurian, 21-11-1950."

Epyris delhiensis, sp. nov.

Female.— Length 7.3 mm. Colour black, with apex of abdomen reddish-brown. Head nearly prognathous; viewed from behind length slightly less than half the width; inter-orbital distance very slightly over three-fourths the width; eyes brownish-black, bare; ocelli reddish-brown, arranged in a nearly equilateral triangle; interocellar distance two-sevenths the ocellocular, which is very slightly less than four times the front ocellar; vertex very finely rugososcaly sculptured, with few shallow, but distinct and broad punctae irregularly scattered margined; just behind the carina on the occiput are arranged closely, stiff, silvery-brown setae; viewed in front length equal to width; interorbital space nearly two-thirds the width of the head; length of eye nine times that of gena; post-orbital two-thirds the length of eye; frons and face sculpture nearly the same as on the vertex, with very few scattered, silvery-brown pubescence. Antennae reddish-brown, inserted above the clypeus, just below an imaginary line joining the lower orbital borders; 13-jointed; scape length two and one-third the width, three times the pedicel and very slightly longer than the pedicel, first and second flagellar joints combined; first flagellar four-fifths the pedicel; second to tenth flagellars equal and are slightly longer than the pedicel; terminal joint one and a half times the penultimate, slighly over half the scape and one and three-fifths the pedicel.

Thorax: Length thrice the width at the region of the tegulae; pronotum slightly more than two-fifths the whole of thorax, sculpture nearly same as on head; mesonotum one-third the pronotum, distinctly finely rugoso-coriaceously sculptured, with few broad and shallow punctae; parapsidal furrows disinct, deep and nearly complete, broadening posteriorly and stopping very slightly above the posterior border of mesothorax as two shallow fovae; lateral furrows deep and anteriorly incomplete; scutellum somewhat less than the mesonotum, sculpture nearly as on mesonotum but more smooth and shiny; metathorax somewhat less than one-sixth the scutellum, roughly irregularly rugoso-coriaceously sculptured; propodeum three-fourths the pronotum and somewhat less than one-third the whole length of thorax; three complete longitudinal carinae, median carina runs down the whole length of propodeum, the laterals converge posteriorly and meet the transverse carina separating the anterior horizontal area from the posterior slanting part; posterior part sharply declivous; the whole of propodeum is traversed by transverse interconnecting carinae; propodeal spiracles lanceolate, somewhat crescent shaped spiracular favae broad, deep and nearly smooth and shiny. Legs dark reddish-brown, tibia and tarsi somewhat lighter. Fore coxa two and a half times the trochanter; femur four and one-third the trochanter; tibia slightly more than half the femur; tibial spur a little less than half the tibia; metatarsus a little less than half the tibia and exactly two-thirds the rest of tarsi combined (Fig. 90). Hind coxa twice the trochanter; femur somewhat more than thrice the trochanter; tibia one and one-fourth the femur; tibial spur two-sevenths the tibia; metatarsus slightly more than half the tibia and nearly three-fifths the rest of tarsi combined; apex of tibia with two or three short, stiff spines; tarsi especially their apices beset with spinous setae; claw bifid (Fig. 88 & 89). Fore wing nearly hyaline, slightly dusky anteriorly; length thrice the breadth; radius slightly less than one-fourth the length of the wing, smoothly curved, arising from nearly the middle of pterostigma; pterostigma reddish-brown, length two and a half times the breadth, with a clear area basally as also anteriorly where it is continuing as the stigmate post-marginal, which latter is slightly less than one-fourth the length of pterostigma; veins light brown; basal nearly half the radius and transversal nearly four-fifths the basal; basal joins subcosta where the latter joins pterostigma; posterior end of transverse veins clear; hind wing with four frenular hooks (Fig. 86 & 87). Abdomen nearly as long as thorax; dorsally slightly arched, apex acuminate; dark reddish-brown to black basally, reddish-brown apically; six tergites distinctly visible; tergites smooth and shiny except the third which is also the largest, which has the anterior half transversely coriaceously striate; ovipositor sheath half the penultimate segment and slightly more than one-third the last tergite; ovipositor reddish-brown, one-fourth the whole length of abdomen.

Holotype female partly dissected on slide No. 63/B and rest on pin labelled: "Delhi, Chowdhary coll., on carrot, Imperial Entomologist, 5-4-1938."

Epyris duttai, sp. nov.

Female.— Length 5.5 mm. Colour black with apex of abdomen dark reddish-brown. Head black; viewed from above length slightly less than two-fifths the width; inter-orbital distance slightly more than five-sixths the width of the head; post-orbital distance slightly more than half the width of eye; eyes brownish-black, bare; vertex emarginate, nearly smooth and shiny; ocelli arranged in an equilateral triangle; interocellar one-fourth the ocellocular, which latter is four times the front ocellar; viewed in front length nine-tenths the width; interorbital distance three-fourths the width of the head; length of eye slightly over five times that of gena; postorbital three-fourths the length of eye; mandibles large, strong set; reddish-brown, with slightly darker apices; clypeus brownish-black truncate with a tooth like process towards the tip; frons and face smooth and shiny, except for faint coriaceous sculpture and covered over by fairly long, silvery-brown pubescence. Antennae dark reddish-brown; inserted near the mouth, below an imaginary line joining the lower orbital borders; 13-jointed; scape two and half times the pedicel; first flagellar three-fifths the pedicel and one-fourth the scape; second somewhat less than twice the first; third, fourth and fifth equal to second; sixth and succeeding segments subequal or very gradually become shorter, except terminal which is half the scape and very slightly more than one and one-fourth the penultimate (Fig. 93).

Thorax: Pronotum one-third the whole length of thorax; sculpture faint and irregular and indistinctly leathery; mesonotum two-sevenths the pronotum, slightly depressed, nearly smooth and shiny; parapsidal furrows distinct and complete; lateral furrows distinct; scutellum as long as mesonotum, sculpture nearly same as on mesonotum; metathorax one-fifth the scutellum, latrally with few depressions; propodeum with five complete, parallel, longidudinal carinae all reaching the transverse carinae, outer ones posteriorly converging, these connected by anastomosing transverse carinae in between giving a rough leathery sculpture to the median area; lateral to this the propodeum is finely and faintly leathery; propodeal spiracles large, lanceolate, somewhat crescent shaped; lateral marginal and basal carinae also present. Legs reddish-brown, with darker coxa, trochanter and femur. Fore coxa three and a half times the trochanter; femur one and two-thirds the coxa; tibia slightly less than four-fifths the femur; tibial spur two-fifths the tibia; metatarsus somewhat less than half the tibia; rest of tarsi one and one-third the metatarsus (Fig. 95). Hind coxa twice the trochanter; tibia slightly more than the femur; larger tibial spur slightly less than one-fourth the tibia: smaller four-fifths the larger: metatarsus slightly less than half the tibia and nearly half the rest of tarsi combined; claw bifid; apices of tarsi provided with thick spinous setae (Fig. 94). Fore wing nearly hyaline, except for slightly dusky appearance anteriorly; length nearly two and three-fourths the breadth; radius slightly more than one-fourth the length of the wing, two and one-third the pterostigma, somewhat smoothly curved, arising from slightly beyond the middle of pterostigma; pterostigma length two and three-fourths the breadth; basally clear as also apically where it is demarcated from the very short post-marginal, which latter is only one-seventh the length of pterostigma; basal slightly more than one-third the radius; transversal somewhat less than the basal, apex of which is clear (Fig. 91 & 92). Abdomen black with reddish-brown apex, slightly longer than thorax; distinctly petiolate; ovipositor including sheath and sting slightly less than one-fourth the length of abdomen and nearly equal to the last two tergites combined; six tergites distinctly visible;

first the largest, rest of them gradually become shorter; tergites smooth and shiny, except the third in which the anterior one-third is faintly coriaceous.

Holotype female, partly dissected on slide No. 64/B labelled: "Pusa, Bengal, G.R.Dutt, 13-3-1908."

Epyris manii, sp. nov.

Male.—Length 2 mm. Colour dark reddish-brown. Head black; viewed from above length half the width; inter orbital distance slightly more than three-fourths the width of the head; vertex finely rugosely sculptured or nearly smooth and shiny, margined; eyes brown, bare; inner orbital borders posteriorly diverging; ocelli yellowish brown; interocellar distance one-third the ocellocular, which latter is nearly five times the front ocellar; viewed in front length slightly more than the width; interorbital distance approximately two-thirds the width of the head; length of eye slightly more than the post-orbital distance; gena extremely reduced; frons and face finely rugosely sculptured; clypeus dark reddish-brown, apex conical with a median longitudinal carina running up to the base of insertion of antennae; mandibles reddish-brown, with a yellowish tinge; palpi nearly the same colour as mandible. Antennae brown, with slightly lighter scape and pedicel, inserted far below the middle of face, on an imaginary line joining the lower orbital borders; 13-jointed; scape slightly longer than the pedicel; first flagellar joint four-fifths the pedicel; second nearly one and a half times the first; third and fourth very slightly longer than second; fifth to seventh equal and very slightly smaller than previous; eighth and ninth slightly smaller than fifth to seventh; tenth very slightly shorter than the pedicel; terminal segment one and a half times the penultimate (Fig. 99).

Thorax: Prothorax one-third the whole length of thorax; mesothorax slightly less than the prothorax; parapsidal furrows distinct and complete; faintly rugosely sculptured, giving a somewhat shagreened apearance; scutellum somewhat convex; two-thirds mesothorax; sculpture same as on mesothorax, with two broad sulci one on either side connected together by a transverse furrow; metathorax short; propodeum reticulately carinate; median longitudinal carina distinct and runs up and joins the transverse carina separating the anterior horizontal area from the posterior slanting part and then continues up to the posterior end; there are two lateral carinae one on either side of the median longitudinal carina and which are indistinct posteriorly; propodeal spiracles small and oval. Legs reddish-brown. Fore coxa nearly one and a half times the trochanter; femur twice the coxa; tibia somewhat smaller than femur; metatarsus half the tibia and slightly longer than the next three tarsi combined; tibial spur one-third the tibia (Fig. 100). Hind coxa very slightly over one and three-fifths the trochanter; femur three and a half times the trochanter; tibia one and one-seventh the femur; metatarsus half the tibia; larger tibial spur one-fourth the tibia and half the metatarsus; smaller three-fifths the larger; rest of tarsi one and half times the metatarsus (Fig. 98 & 101). Fore wing length two and two-thirds the breadth; radius four times the basal, which is very slightly longer than the transversal; rest of details and hind wing as in fig. 96 and 97. Abdomen dark reddish-brown, somewhat dorsally bent, much longer than the thorax; six tergites distinctly visible; the first two larger than the rest; tergites smooth and shiny, with few scattered setae.

Female.—Length 2.8 mm. Colour dark reddish-brown to black. Head black; completely prognathous; viewed in front length one and one-seventh the width; inter-orbital distance nearly three-fourths the width of the head; length of eye four times that of gena; post-orbital distance two-thirds the length of eye, eyes brown, bare, vertex smooth and shiny, emarginate; ocelli arranged in a triangle; inter-ocellar distance one and one-third the front ocellar, which latter is slightly less than one-fourth the ocellocular; frons and face smooth and shiny, very faintly rugoso-coriaceously sculptured, nearly smooth and shiny; clypeus reddish-brown, somewhat convex; mandibles reddish-brown; palpi brown. Antennae reddish-brown, with short stiff setae, inserted far below the middle of face, somewhat below an imaginary line joining the lower orbital borders, on the clypeus; scape one and two-thirds the pedicel, length two and a half times the width at apex; pedicel length nearly twice the width; first flagellar half the pedicel, second one and a half times the first; third, fourth, fifth and sixth subequal and five-sixths the pedicel; seventh, eighth, ninth and tenth gradually becoming smaller; terminal segment one and a half times the penultimate and somewhat longer than the pedicel (Fig. 104).

Thorax: Pronotum twice the mesonotum; parapsidal furrows distinct and complete, slightly dilated posteriorly into small foveae; scutellum slightly shorter than mesonotum; metathorax not very distinct, nearly fused with scutellum; propodeum nearly two-thirds the rest of thorax combined and slightly over thrice the scutellum; reticulately carinate with few distinct transverse carinae and three longitudinal carinae; median longitudinal carina meets the transverse carina separating the anterior horizontal area from posterior slanting part, lateral carinae faint; lateral marginal and basal carinae also present. Legs reddish-brown. Fore coxa twice the trochanter; femur nearly four times the trochanter; tibia slightly more than two-thirds the femur; metatarsus half the tibia rest of tarsi two-thirds the tibia and somewhat less than one and a half times the metatarsus; tibial spur slightly less than half the tibia and somewhat less than the metatarsus (Fig. 106). Hind coxa twice the trochanter; femur nearly four times the trochanter; tibia slightly longer than the femur; tibial spur one-third the length of tibia; metatarsus somewhat more than half the tibia, which latter is equal to the rest of tarsi combined (Fig. 105). Fore wing length thrice the breadth; radius moderately long, one-third the length of the wing and nearly five times the basal; transversal slightly less than one and a half times the basal; rest of details and hind wing as in fig. 102 and 103. Abdomen dark reddish-brown, somewhat shorter than thorax; basally bent, drosally slightly arched; tergites smooth and shiny, except for few short pubescence; apex somewhat lighter in colour than the rest of abdomen and with longer pubescence; six tergites distinctly visible, the first the largest and cover more than one-third the whole length of abdomen; apex acuminate with ovipositor exserted and as long as ovipositor sheath.

Holotype male, completely dissected on slide No. 9/B; allotype female, completely dissected on slide No. 19/B, labelled: "On wing, St. John's College, Agra, coll. Chandy Kurian, 10-9-1949 and 1-1-1950."

Epyris patnae, sp. nov.

Male.—Length 2.8 mm. Colour dark reddish-brown to black. Viewed from above length nearly half the width; interorbital distance somewhat more than two-thirds the width of the head; postorbital nearly equal to width of eye; eyes dark brown, sparsely pubescent; vertex rugosely sculptured, posteriorly margined, with few scattered silvery-white pubescence; ocelli reddish-brown, interocellar distance one and a half times the front ocellar and three-fourths the ocellocular, which latter is twice the front ocellar; occiput faintly transversely striate; viewed in front length slightly more than the width; inter-orbital distance somewhat less than two-thirds the width; postorbital five-sixths the length of eye, which latter is four and a half times that of gena; frons and face rugosely sculptured with very few scattered silvery-white pubescence. Clypeus dark reddish-brown, irregularly transversely rugoso-carinate; mandibles reddish-brown, with one acute tooth; maxillary and labial palpi yellowish-brown, former five jointed. Antennae dark reddish-brown; inserted on the clypeus below the middle of face, on an imaginary line joining the lower orbital borders; 13-jointed; scape slightly longer than the pedicel; first flagellar slightly more than two-thirds the pedicel and slightly less than three-fourths the scape; second flagellar slightly longer than first; rest of segments subequal and are slightly longer than second, except the penultimate which is equal to second flagellar; terminal one and one-fourth the penultimate and equal to scape (Fig. 107).

Thorax: Length two and a half times the width at the region of the tegulae; pronotum three-eighths the whole length of thorax, distinctly rugosely sculptured, with a shagreened appearance; mesonotum one-third the pronotum, sculpture same as pronotum; tegulae reddish-brown; parapsidal furrows not very distinct, anteriorly incomplete; scutellum very slightly longer than mesothorax, nearly contiguous with propodeum; metathorax nearly obliterated in the middle; faintly rugoso-coriaceously sculptured; propodeum slightly over two and a half times the scutellum; three longitudinal carinae of which the median runs up to the beginning of the posterior declivous area, where there is no transverse carina differentiating the anterior and posterior parts; median carina continue in the posterior part of propodeum as a faint line, lateral carinae stop short half way in the anterior area of propodeum; many transverse carinae anastomose with the longitudinal ones giving the whole a leathery transversely striate appearance; propodeal spiracles medium sized and oval; lateral marginal and basal carinae present. Legs reddish-brown; fore coxa nearly thrice the trochanter; femur five times the trochanter; tibia slightly less than four-fifths the femur; tibial spur a little less than two-fifths the tibia; metatarsus nearly three-fifths the tibia and five-sixths the rest of tarsi combined; claw bifid; first tooth acute, second blunt (Fig. 110). Hind coxa twice the trochanter; femur slightly over four times the trochanter; tibia a little less than the femur; longer tibial spur nearly one-fourth the tibia and smaller half the longer; metatarsus nearly half the tibia and very slightly more than half the rest of tarsi combined; apices of tibia and tarsi beset with spinous setae (Fig. 111). Fore wing two and three-fourths as long as broad; radius one-third the length of wing, arising from apex of pterostigma, smoothly curved; pterostigma length thrice the breadth, basally with a clear area, apically nearly truncate; post-marginal absent; basal joins subcosta somewhat ahead of the latter joining the pterostigma, slightly more than one-fourth the radial; transversal as long as basal; two closed basal cells; costa and subcosta coalesced; pterostigma and veins light brown; hind wing with four frenular hooks; rest of venation and pubescence as in fig. 108 and 109. Abdomen six-sevenths the thorax; dark reddish-brown to black; basally narrowed, but no distinct petiole; oval, dorsally slightly arched; five tergites visible; first the largest and cover nearly half the abdomen; second less than half the first and rest gradually become shorter.

Holotype male, partly dissected on slide No. 90/B and rest on pin; paratype 1 male, partly dissected on slide No. 68/B and rest on pin, both labelled: "Parasitic, Patna, C. No. 881, 26-5-1911."

Key to Oriental species of *Rhabdepyris* Kieffer

1.	Legs reddish-yellow or lemon-yellow	2
	Legs darker, reddish-brown to dark brown	3
2.	Scape distally and basal segments and sometimes also the middle segments of flagellum lemon yellow; wings brownish	*fuscinervis* (Cameron)
	Antennae uniformly reddish-yellow except the slightly darker apical segments; wings hyaline	*foveatus* (Cameron)
3.	Propodeum with five longitudinal carinae; pterostigma and veins yellow; legs not uniformly coloured	4
	Propodeum with seven longitudinal carinae; pterostigma and veins brown; legs completely reddish-brown	*agraeensis*, sp. nov.
4.	Post-marginal wanting; eye one-third longer than occiput ...	*defectus* Kieffer
	Post-marginal longer than basal; eye more than twice as long as occiput	...*luzonicus* Kieffer

Rhabdepyris agraensis, sp. nov.

Female.—Length 5 mm. Colour black with dark reddish-brown hue in the abdomen. Head nearly prognathous; viewed from above length slightly less than the width; inter-orbital distance slightly more than half the width of the head; eyes brownish-black, with few short pubescence; vertex somewhat leathery with distinct and uniformly scattered rugose punctae, with many broad depressions from which setae are given off, posteriorly margined; ocelli reddish-brown, arranged in a triangle; interocellar distance two-thirds the ocellocular, which latter is twice the front ocellar, frons and face leathery with distinct and uniformly scattered rugose punctae; length of eye ten times that of gena, post-orbital one-fourth the length of eye; clypeus nearly spatulate, with a median ridge; mandible reddish-brown, 3-toothed, the first tooth acute, the rest blunt. Antennae reddish-brown to black, scape and pedicel lighter; inserted behind the clypeus on either side, on two raised knobs and below the level of the lower orbital borders; scape twice the pedicel; first flagellar somewhat longer than pedicel; rest of flagellar joints gradually become shorter; penultimate joint slightly less than half the first flagellar; terminal one and a half times the penultimate, one-third the scape and two-thirds the pedicel (Fig. 114).

Thorax: Length two and one-third the width; pronotum somewhat over twice the mesonotum, distinctly rugosely sculptured, with few broad, scattered depressions, from which setae are given off; mesonotum sculpture nearly the same as pronotum; parapsidal furrows faint; two faint, short, lateral foveae on either side; scutellum convex, sculpture same as mesonotum, but finer; metathorax short, half the scutellum; propodeum nearly equal to rest of thorax combined, roughly reticulately carinate; seven longitudinal carinae, one median longitudinal and three pairs of lateral, three on either side; these with the anastomosing transverse carinae giving it a reticulately carinate appearance; only median longitudinal run the whole length of propodeum, others stop at the transverse carina separating the anterior horizontal area from the posterior slanting part, lateral marginal and basal carinae present; median longitudinal carina has a row of small foveae on either side; on the corners where anterior and posterior parts of propodeum meet are two tooth-like processes, one on either side; propodeal spiracles somewhat large and lanceolate. Legs reddish-brown. Fore coxa somewhat less than thrice the trochanter; femur more than one and three-fourths the coxa; tibia slightly over three-fourths the femur; metatarsus slightly over half the tibia; rest of tarsi one and a half times the metatarsus; large tibial spur one-third the tibia, smaller two-fifths the larger (Fig. 115). Hind coxa two and one-third the trochanter; femur more than five times the trochanter tibia somewhat longer than femur; longer tibial spur slightly less than one-fifth the tibia; smaller slightly more than half the larger; metatarsus slightly less than half the tibia; rest of tarsi somewhat less than twice the metatarsus; claw bifid, second tooth very blunt (Fig. 116 & 117). Fore wing nearly hyaline except for slightly dusky areas in the basal cells and around the radius anteriorly; length two and three-fourths the breadth; radius moderately long, one-fourth the length of the wing, arising from apical end of pterostigma, smoothly curved, continuing at apex as a faintly coloured line anteriorly for some distance; pterostigma length thrice the width, basally with a clear patch, apically very slightly conically almost bluntly produced, beyond which is a small clear patch; basal one-third the radius and somewhat shorter than the transversal; hind wing with four frenular hooks; rest of details as in fig. 112 and 113. Abdomen nearly one and two-fifths the thorax, tergites very finely rugoso-coriaceously sculptured with very short pubescence; apices of tergites reddish-brown; six tergites distinctly visible; intertergital constrictions very prominent especially between third, fourth, fifth and sixth tergites.

Holotype female, partly dissected on slide No. 22/B and rest on pin, labelled: "In room, St. John's College, Agra, S.N. Rao coll. 23-3-1950."

Apenesia raonis, sp. nov.

Female.— Length 4.3 mm. Colour dark reddish-brown to black. Head black; nearly prognathous; viewed in front length nearly one and one-eighth the width; interorbital distance nearly three-fourths the width of the head; vertex roughly rugose and somewhat leathery: ocelli arranged in a broad triangle interocellar distance half the ocellocular, which latter is four times the front ocellar; frons and face sculpture same as that of vertex; eyes brownish-black, pubescent; length of eye thrice the gena; post-orbital one and one-third the length of eye; clypeus somewhat spatulate with a median carina; mandible strong, reddish-brown. Antennae reddish-brown; inserted behind the clypeus on either side, below the lower orbital borders; 13-jointed; scape two and one fourth as long as pedicel, length two and two-thirds the width at apex; pedicel length nearly twice the width at apex; first flagellar joint slightly more than half the pedicel, second one and a half times the first; third to sixth subequal and same length as second; seventh to tenth very gradually become shorter; penultimate joint two-thirds the pedicel; terminal somewhat less than twice the penultimate; slightly over half the scape and one and one-fifth the pedicel; rest of details as in fig. 120.

Thorax: Length nearly two and three-fifths the width at the region of the tegulae; pronotum much longer than mesothorax, rugoso-punctate; mesonotum short somewhat less than half the pronotum, sculpture same as latter; parapsidal furrows absent; two or three broad foveae on either side of mesonotum scutellum absent; propodeum with five longitudinal carinae which with the anastomosing transverse carinae, give a reticulately carinate appearance; propodeum not margined behind; propodeal spiracles nearly round. Legs short and stout; reddish-brown, with yellowish-brown tarsi. Fore coxa one and two-thirds the trochanter, which latter is two-sevenths the femur; tibia five-sixths the femur; metatarsus slightly less than half the tibia; rest of tarsi combined equal to half the tibia and slightly longer than metatarsus; tibial spur slightly less than one-third the tibia (Fig. 121). Hind coxa two and one-fourth the trochanter; femur three and a half times the trochanter; tibia somewhat longer than femur and four times the trochanter; metatarsus two-fifths the tibia and half the rest of tarsi combined; longer tibial spur slightly less than one-fourth the tibia, smaller nearly half the larger; claw bifid; tarsi especially at the apices beset with spinous setae; rest of details as in fig. 122 and 123. Fore wing length slightly less than thrice the breadth; radius nearly one-third the whole length of wing; basal slightly longer than one-fourth the radius; transversal somewhat longer than the basal; hyaline with two somewhat dusky areas one at the apex of basal cells and another in the radial area; pterostigma stigmate, length three and one-third the breadth, basal one-third clear, rest of pterostigma and veins light brown; radius arising from apex of pterostigma, very smoothly curved, a clear spot anterior to the apex of pterostigma; rest of details and hind wing as in fig. 118 and 119. Abdomen black, apex reddish-brown; slightly shorter than thorax, with a short petiole; six tergites distinctly visible; apex of tergites with a reddish-violet hue, some of them also with a golden-yellow lustre; tergites smooth and shiny, except for extremely fine sculpture and few silvery-white setae disposed laterally; ovipositor-sheath reddish-brown, two thirds the last tergite; ovipositor golden-brown, slightly exserted, about half the ovipositor sheath.

Holotype female, partly dissected on slide No. 23/B and rest on pin, labelled: "In room, St. John's College, Agra, coll S.N. Rao, 23-3-1950."

This is the first record of the genus[1] from India.

KEY TO ORIENTAL SPECIES OF *Chlorepyris* KIEFFER

1.	Claw with one tooth; mandible with four teeth	*unidens* Kieffer
	Claw bidentate; mandible with 1 to 5 teeth	2
2.	Claw bidentate; mandible with 1 or 2 teeth	3
	Claw bidentate; mandible with 3 teeth	4
	Claw bidentate; mandible with 5 teeth	5
3.	Propodeum somewhat elongate, with three longitudinal carinae, median complete and joins the transverse carina separating the anterior and posterior parts; mandible with one tooth. ...	*pusaena*, sp. nov.
	Propodeum transverse or somewhat elongate, with five longitudinal carinae; mandible with one or two teeth	6
4.	Parapsidal furrows strongly converging posteriorly; wings nearly hyaline; propodeum quadrate, with five complete parallel longitudinal carinae.	*conjunctus* (Kieffer)
	Parapsidal furrows somewhat converging behind; wings slightly brownish; propodeum longer than broad; three complete and two incomplete parallel longitudinal carinae, the lateral outer ones converging behind	*mackenziei*, sp. nov.
5.	Parapsidal furrows parallel; wings yellow; head smooth and shiny; palpi yellow	7
	Parapsidal furrows somewhat converging behind; head irregularly rugosely sculptured; palpi dark reddish-brown ...	*biharina*, sp. nov.
6.	Propodeum somewhat elongate, scarcely longer than broad with five contiguous longitudinal carinae, only the median carina reaching the posterior margin; pterostigma truncate distally; scape blackish-brown	*raripilus* Kieffer
	Propodeum somewhat elongate, distally longer than broad with five contiguous longitudinal carinae, only the median carina reaching the posterior margin; pterostigma apically conically rounded; scape reddish-brown	*sancti-pauli* Kurian

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[1] 1863. *Scleroderma*, FRED SMITH, *Proc. Linn. Soc. London*, 7:27.
1874. *Apenesia*, WESTWOOD, *Thesaur. ent. Oxon.*, 120.
1881. *Apenesia*, WESTWOOD, *Trans. ent. Soc. London*, 130.
1904. *Aeluroides*, TULLGREN, *Ark. Zool.*, 1:428.

Propodeum somewhat transverse, with five contiguous and continuous longitudinal carinae; pterostigma distally tapering ... *raptor* Kieffer

7. Head nearly smooth and shiny, veins and pterostigma yellow, fore tibia and tarsi red ... ... *flavipennis* Kieffer

Head more shiny; veins and pterostigma paler; fore tibia and tarsi pale yellowish-brown ... ... *similis* Bridwell

Chlorepyris biharina, sp. nov.

Male.—Length 3.8 mm. Colour black, except for reddish-brown legs and lateral areas of abdomen. Head viewed from above length half the width; inter-orbital three-fourths the width of the head; post-orbital two-thirds the width of eye; vertex broad, margined, irregularly rugosely sculptured; ocelli reddish-brown arranged in a triangle; interocellar distance very slightly over half the ocellocular, which latter is two and one-third the front ocellar, viewed in front length somewhat shorter than the width; interorbital distance very slightly over three-fifths the width; length of eye nearly six times that of gena; post-orbital distance nearly half the length of eye; eyes brown, bare; frons and space rugosely sculptured, punctae large; clypeus black, apex conical, nearly beak-like, with a median longitudinal carina running up to the base of the antenae, finely sculptured with a faint scally appearance; mandibles strong, reddish-brown, with five teeth; palpi dark reddish-brown. Antennae reddish-brown, inserted just above the clypeus, below the lower orbital borders; 13-jointed; scape somewhat less than twice the pedicel; first flagellar nearly as long as scape; second longer than first; third slightly longer than second; fourth to tenth flagellar joints gradually become shorter (Fig. 126).

Thorax: Black; length twice the width at the region of the tegulae; pronotum slightly more than the mesonotum, rugosely sculptured with some broad pits; mesonotum faintly rugoso-leathery sculptured, giving a shagreened appearance, with very few broad pits; parapsidal furrows deep and complete, posteriorly slightly converging and broadening into foveae; tegulae reddish-brown; scutellum slightly more than half the mesothorax, with two pits anterio-laterally, sculpture nearly same as mesonotum, but somewhat smoother; metathorax dull, irregularly sculptured; propodeum twice the scutellum, roughly rugoso-reticulately carinate, giving a leathery appearance with five longitudinal carinae, one median and two pairs of lateral, two on either side; these join the transverse carina that separates the anterior horizontal area from the posterior slanting part; between the median and lateral longitudinal carinae there are many broad pits. Legs reddish-brown. Fore coxa one and three-fourths the trochanter; femur three and a half times the trochanter; tibia three-fourths the femur; tibial spur two-fifths the tibia; metatarsus slightly less than two-thirds the tibia and one and one-third the next three tarsi combined (Fig. 129). Hind coxa slightly less than twice the trochanter; femur nearly four times the trochanter; tibia nearly one and one-seventh the femur; tibial spur larger one two-sevenths the tibia and smaller two-thirds the larger; metatarsus very slightly less than half the tibia and somewhat more than two-thirds the rest of tarsi combined;

claw bifid; rest of details as in fig. 127 and 128. Fore wing length two and one-third the breadth; subcosta and pterostigma brown; rest of veins lighter; radial very slightly longer than one-fourth the length of the wing; basal slightly more than two-fifths the radial; transversal two-thirds the basal; costa and subcosta fused for basal one-third; pterostigma length thrice the breadth; hind wing with five frenular hooks (Fig. 124 & 125). Abdomen slightly longer than thorax; black, with reddish-brown apex; elongate-oval; eight tergites distinctly visible.

Holotype male, partly dissected on slide No. 29/B and rest on pin, labelled: "H. Inglis coll. Banhar, Bihar, 4-4-1919."

Chlorepyris mackenziei, sp. nov.

Female.—Length 6.8 mm. Colour black, with apex of abdomen reddish-brown. Head viewed from above somewhat transverse, length slightly over four-sevenths the width; inter-orbital distance six-sevenths the width of the head; vertex finely rugosely leathery sculptured, margined with a few silvery-brown setae; occiput excavate; faintly rugosely sculptured; eyes brown, bare; ocelli reddish-brown arranged in a somewhat broad triangle; interocellar space slighty more than one-third the ocellocular, which latter is four and one-fourth the front ocellar; face very faintly and finely leathery sculptured, with a few large, scattered, rugose punctae; viewed in front length one and one-ninth the width; inter-orbital distance two-thirds the width of the head; length of eye three and three-fourths the length of gena; mandible three toothed, first tooth large. Antennae reddish-brown; inserted below the middle of face, just above the clypeus; 13-jointed; scape thrice the pedicel; first flagellar three-fifths the pedicel; second over one and a half times the first and equal to pedicel; rest of flagellar joints equal to second, except the terminal which is slightly longer than pedicel and first flagellar combined, somewhat more than half the scape and nearly one and three-fourths the penultimate joint; rest of details as in fig. 132.

Thorax: Length two and two-thirds the width; pronotum two-fifths the length of thorax, faintly rugosely sculptured, with a few large punctae and few long yellowish-brown setae; mesonotum three-eighths the pronotum; sculpture more irregular and smooth; parapsidal furrows somewhat converging behind; scutellum two-thirds the mesonotum, somewhat flattened, nearly smooth and shiny; metathorax small, very slightly longer than one-third the scutellum; propodeum somewhat shorter than pronotum, with five longitudinal carinae, one median and two pairs of lateral, two on either side; there are transverse anastomosing carinae in between the longitudinal, giving the whole a somewhat reticulately sculptured appearance; the lateral marginal and basal carinae present, as also the transverse carina demarcating the anterior horizontal area from the posterior slanting part; longitudinal median carina runs up the whole length of propodeum, whereas the laterals stop at the transverse carina; propodeal spiracles large, lanceolate, with the orifice reddish-brown. Legs reddish-brown, with darker coxae and femora. Fore coxa one and two-thirds the trochanter; femur three and one-third as long as trochanter; tibia three-fourths the femur; tibial spur two-fifths the tibia; metatarsus nearly half the tibia and slightly over three-fourths the rest of tarsi combined (Fig. 133). Hind coxa slightly over thrice the trochanter; femur two and a half times the trochanter; tibia one and one-eighth the femur; larger tibial spur slightly less than one-third the tibia and smaller somewhat over half the larger; metatarsus a little over half the tibia and somewhat less than three-fifths the rest of tarsi combined; claw bifid (Fig. 134 & 135). Fore wing slightly brownish or clouded; length nearly thrice the breadth; radial slightly less than two-sevenths the length of the wing; basal three-sevenths the radial; transversal nearly three-fourths the basal; rest of details and hind wing as in fig. 130 and 131. Abdomen somewhat shorter than thorax; petiolate, petiole one-third the first tergite; dorsally slightly arched; seven tergites distinctly visible; first three tergites much larger than the rest and together come to about three-fourths the whole length of abdomen; tergites nearly smooth and shiny, except the last four tergites and the sides of the first three which are covered over by silvery-white pubescence; first three tergites black; second apically with a reddish-brown hue; fourth to seventh reddish-brown; apex tapering; ovipositor-sheath slightly shorter than the sting labelled which is as long as the petiole.

Holotype female, partly dissected on slide No. 81/B and the rest on pin, "Chapra, Bengal, Mackenzie coll."

Chlorepyris pusana, sp. nov.

Female.—Length 2.6 mm. Colour black. Viewed from above length of head slightly more than half the width; interorbital distance very slightly more than three-fourths the width; post-orbital distance two-thirds the width of eye; eyes brown, bare; ocelli golden-brown, arranged in a triangle; interocellar distance three-fourths the ocellocular which latter is two and one-third the front ocellar; vertex broad, very faintly and finely sculptured, with very few short, scattered, setae, posteriorly emarginate; viewed in front length somewhat less than the width; inter-orbital distance two-thirds the width of the head; length of eye slightly more than one and a half times the post-orbital and thrice the gena; frons and face finely coriaceously sculptured, with a median carina; mandible reddish-brown, with one tooth. Antennae dark reddish-brown, inserted far below the middle of face, below the lower orbital borders; 13-jointed; scape one and four-fifths the pedicel; first flagellar half the pedicel; second slightly over one and a half times the first; third and succeeding segments subequal and nearly equal to the second; except the terminal which is slightly less than twice the penultimate (Fig. 137).

Thorax: Dark reddish-brown to black; length slightly less than two and half times the width at the region of tegulae; prothorax slightly less than one-third the whole length of thorax; rugoso-shagreened; mesothorax half the prothorax, sculpture nearly same as prothorax; parapsidal furrows faint, but complete; scutellum slightly longer than mesothorax, faintly coriaceously sculptured; metathorax very short, medially almost obliterated; nearly smooth and shiny, with very few foveae on either side; propodeum somewhat more than one-third the thorax; rugoso-carinately sculptured with a leathery appearance; a median longitudinal carina present which joins the transverse carina that separates the anterior horizontal area from the posterior slanting part; there are two lateral carinae that stop at two-thirds the distance from the anterior end and do not join the transverse carina; lateral marginal and basal carina present; propodeal spiracles medium sized, lanceolate. Legs dark-reddish-brown. Fore coxa twice the trochanter; femur four times the trochanter; tibia six-sevenths the femur; metatarsus half the tibia and three-fourths the rest of tarsi combined (Fig. 139). Hind coxa nearly thrice the trochanter; femur nearly five times the trochanter; tibia slightly longer than femur; larger tibial spur one-fourth the tibia and smaller slightly less than four-fifths the larger; metatarsus somewhat longer than half the tibia and one and one-fourth the next two tarsi combined; claw bifid (Fig. 138 & 140). Fore wing length nearly thrice the breadth; pterostigma and subcosta brown; rest of veins very light brown; radial slightly less than one-third the length of the wing; basal one-fourth the radial; transversal slightly longer than the basal; pterostigma length twice the breadth; radius arising from apex of pterostigma; rest of details as in fig. 136. Abdomen dark reddish-brown; apex reddish-brown; petiolate, basally bent, dorsally somewhat arched; seven tergites distinctly visible; first five tergites subequal, the sixth two-thirds the fifth; seventh about half the sixth; tergites nearly smooth and shiny, except for faintly coriaceous sculpture giving them a shagreened appearance from the third tergite onwards; ovipositor twice the last tergite.

Holotype female, partly dissected on slide No. 99/B and rest on pin, labelled: "In Lab., Pusa, C.S.Misra, 5-5-1922."

Chlorepyris sancti-pauli Kurian

1954. *Chlorepyris sancti-pauli*, KURIAN, *Agra Univ. J. Res.* (*Sci.*) 3(2) : 423-427.

To this species I refer No. 142/C recently described by me (*loc. cit.*)

Pristepyris agraensis Kurian

1952. *Pristepyris agraensis*, KURIAN, *Agra. Univ. J. Res.* (*Sci.*), 1 : 68-69.

To this species I refer No. 5/B recently described by me (*loc. cit.*) This genus[1] was recorded for the first time from the Oriental region.

KEY TO ORIENTAL SPECIES OF *Neodisepyris*.

1. Interocellar distance twice or more than twice the front ocellar ... *bombayensis*, sp. nov.
   Interocellar less than twice the front ocellar 2
2. Ocellocular thrice or more than thrice the front ocellar ... 3
   Ocellocular less than two and a half times the front ocellar ... *duni*, sp. nov.
3. Ocellocular thrice the front ocellar; scape one and two-thirds the pedicel and three-fourths the pedicel and first flagellar combined, hind wing with four frenular hooks ... ... *indicae*, sp. nov.

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[1] 1905. *Pristepyris*, KIEFFER, *Ann. Soc. Sci. Bruxelles*, 29 : 118.

Ocellocular four times the front ocellar; scape two and a half times the pedicel and one and a half times the pedicel and first flagellar combined; hind wing with four frenular hooks ...	*shishami*, sp. nov.
Ocellocular slightly less than four times the front ocellar; scape two and a half times the pedicel and one and half times the pedicel and first flagellar combined; hind wing with five frenular hooks	*pusae*, sp. nov.

Neodisepyris, gen. nov.

Head viewed in front nearly quadrate, nearly as long as broad and almost as broad as thorax; antennae inserted generally on two knob-like projections above the clypeus; 13-jointed; eyes sparsely pubescent; pronotum distinctly long; mesonotum less than half the pronotum; parapsidal furrows complete, broadened posteriorly and converging towards the posterior end; scutellum less than the mesonotum, somewhat convex with two deep pits laterally towards the anterior end; propodeum slightly less than pronotum and somewhat longer than mesonotum, scutellum and metathorax combined; lateral and basal carinae present as also median longitudinal carina and the transverse carina demarcating the anterior horizontal area from the posterior slanting part; wings nearly hyaline, with prostigma and pterostigma; two closed basal cells; basal ending at the base of prostigma; basal and transversal arising from the same place and subequal; femora swollen, claw bifid; radial long; two and a half times or more than the basal. Abdomen nearly as long as thorax Genotype *Neodisepyris bombayensis*, sp. nov.

This genus runs to *Disepyris* in couplet No. 50 in Kieffer's key to genera of Bethylidae,[1] but is easily distinguished by the eyes being sparsely pubescent; parapsidal furrows complete; propodeum slightly less than pronotum; costa and subcosta almost fused and basal ending at the base of pterostigma.

Neodisepyris bombayensis, sp. nov.

Female Length 4.5 mm. Colour black. Head black; viewed from above length half the width; width of eye somewhat over twice the post-orbital distance; eyes brown, with few short, silvery-white hairs; vertex finely rugosocoriaceously sculptured, with few broad punctae irregularly scattered and silvery-white pubescence with a brownish tinge, distinctly margined; ocelli reddish-brown; interocellar distance twice the front ocellar and half the ocellocular, which latter is four times the front ocellar; occiput coriaceously sculptured; viewed in front length slightly more than the width; inter-orbital distance nearly two-thirds the width of head; length of eye nearly seven times that of gena and one and three-fourths the post-orbital distance; frons and face finely rugosely sculptured, with many deep and broad punctae, with raised prominences at the place of insertion of the antennae, black except region of face just above clypeus; clypeus dark reddish-brown, with few silvery-white pubescence, apically nearly rounded, medially somewhat raised; mandibles strong,

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[1] KIEFFER, 1914. *Das Tierreich*, 41 : 228.

reddish-brown. Antennae dark brown with a reddish tinge; 13-jointed; scape length two and a half times the width, nearly two and a half times the pedicel; pedicel length one and one-fourth the width; first flagellar six-sevenths the pedicel; second one and one-fourth the first; third and succeeding segments subequal, nearly equal to second and gradually decrease in size; except the terminal which is slightly less than twice the penultimate and approximately two-thirds the scape; few of the apical and basal flagellar joints slightly longer than broad; rest of them as long as broad (Fig. 141).

Thorax: Length two and three-fifths the width at the region of the tegulae; pronotum long, finely rugosely sculptured, with many broad punctae scattered throughout, from which are given off silvery-white setae; mesonotum slightly more than three-fourths the pronotum, sculpture nearly same as pronotum, but the broad punctae are irregularly scattered and mostly disposed posteriorly; parapsidal furrows nearly complete, anteriorly fainter and posteriorly somewhat dilated, ending slightly away from the margin; lateral furrows short, placed posterio-laterally; tegulae reddish-brown; scutellum two-thirds the mesonotum, sculpture nearly same as latter, but the broad punctae are sparse, with two deep and broad foveae anterolaterally; metathorax short and irregularly sculptured; propodeum nearly equal to mesonotum, scutellum and metathorax combined, divided by a transverse carina into anterior horizontal and posterior slanting parts; anterior area with five longitudinal carinae, one median and four lateral, two on either side, inner laterals converge and join the median at the transverse carina, outer diverging and joining the lateral marginal carinae; lateral marginal carinae continue in the posterior aspect of propodeum as the basal carina; median longitudinal carina continue to the very apex of propodeum; in anterior area the parallel carinae are interconnected by irregularly branching transverse carinae, giving the whole area a roughly reticulately sculptured appearance; in posterior part sculpture nearly same as anterior, but on each side of median carina it is comparatively smoother and rugoso-reticulately sculptured. Fore coxa slightly over one and a half times the trochanter; femur approximately four and a half times the trochanter; tibia three-fourths the femur; tibial spur two-fifths the tibia; metatarsus slightly less than half the tibia, and five-sixths the rest of tarsi combined (Fig. 144). Hind coxa one and three-fourths the trochanter; femur three times the trochanter; tibia one and one-eighth the femur; larger tibial spur nearly one-fifth the tibia and smaller half the larger; metatarsus two-fifths the tibia and three-fifths the rest of tarsi combined; claw falcate, 2-toothed, teeth acute (Fig. 145 & 146). Fore wing length nearly thrice the breadth; prostigma length slightly over twice the breadth; pterostigma length two and one-third the breadth, slightly less than twice the prostigma; radius two-sevenths the length of wing; basal one-third the radius; transversal nearly same as basal; radial somewhat over four times the pterostigma; pterostigma dark reddish-brown; prostigma, costa and radial yellowish-brown; rest of veins yellow; hind wing with five frenular hooks; setation and other details as in fig. 142 and 143. Abdomen black, apex reddish-brown, somewhat longer than thorax; seven tergites distinctly visible; tergites nearly smooth and shiny except faintly coriaceously sculptured appearance anteriorly and for a few shallow punctae from which are given off brown hairs, mostly disposed posterio-laterally; second and following tergites gradually become shorter, until the penultimate is somewhat longer than the previous one; last tergite nearly half the penultimate; ovipositor-sheath as long as the last tergite, ovipositor three-fourths the sheath, reddish-brown.

Holotype female, partly dissected on slide No. 137/B and rest on pin, labelled: "R. Palghar Range, N. Thana, Bombay, ex : 25-7-1939, P. 514, RRD 693, 10-8-1939".

Neodisepyris duni, sp. nov.

Male.—Length 5.4 mm. Colour black, with apex of abdomen reddish-brown. Head viewed from above length half the width; inter-orbital distance three-fourths the width of the head; width of eye one and one-fourth the post-orbital; eyes brownish-black; sparsely pubescent; vertex finely coriaceously sculptured, with few shallow punctures, somewhat broad posteriorly; ocelli greyish-brown; interocellar distance one and one-fifth the front ocellar and slightly more than half the ocellocular, which latter is slightly more than twice the front ocellar; frons and face same sculpture as vertex, with few silvery-brown setae; viewed in front length somewhat less than the width; interorbital distance nearly two-thirds the width of the head; length of eye six times that of gena and one and a half times the postorbital distance; clypeus reddish-brown, apex rounded; mandible reddish-brown, 3-dentate, first tooth brown and acute and rest two blunt. Antennae reddish-brown; inserted below an imaginary line joining the lower orbital borders on two reddish-brown knob-like prominences just above the clypeus; 13-jointed; scape two and one-third the pedicel; first flagellar four-fifths the pedicel; second one and one-fourth the first; third to fifth equal to second and the succeeding segments very gradually become shorter except the terminal which is slightly over one and one-third the penultimate, nearly half the scape and slightly longer than the pedicel (Fig. 149).

Thorax black, with a dark reddish-brown tinge in a few places; length two and one-fourth the width; pronotum long, faintly rugoso-coriaceously sculptured, with some shallow, somewhat broad, irregularly scattered pits; mesonotum nearly one-third the pronotum, same sculpture, but more distinct; parapsidal furrows deep, distinct and complete; posteriorly broadened into foveae; lateral furrows distinct; scutellum one and one-fourth the mesonotum, indistinctly and irregularly sculptured, with two oval foveae anterio-laterally placed; metanotum nearly one-fourth the scutellum, sculpture not very distinct propodeum one and one-fourth the mesonotum, scutellum and metathorax combined; anterior area reticulo-carinately sculptured, carinae branching and mostly transversely disposed; median longitudinal carina distinct, which continues beyond transverse carina down to the very apex of propodeum; two lateral longitudinal carinae, one on either side of the median, branch off and do not reach the transverse carina separating the anterior horizontal area from the posterior declivous part; lateral marginal carinae continue in the posterior aspect of propodeum as basal carina; the slanting posterior part rugoso-carinately sculptured; propodeal spiracles narrow and lanceolate. Legs reddish-brown. Fore coxa somewhat over twice the trochanter; tibia somewhat over three-fifths the femur; tibial spur two-fifths the tibia; metatarsus half the tibia and nearly one and two-fifths next three tarsi combined (Fig. 150). Hind coxa thrice the trochanter; femur five times the trochanter; tibia somewhat longer than femur; tibial spur nearly one-fourth the tibia; metatarsus slightly less than half the tibia and two-thirds the rest of tarsi combined (Fig. 151 & 152). Fore wing length slightly less than thrice the breadth; radial two-sevenths the length of wing; basal slightly less than one-third the radial; transversal one and one-sixth the basal; prostigma length one and one-third the breadth; pterostigma two and two-thirds prostigma, length nearly two and three-fourths the breadth; radial somewhat slightly more than two and one-fourth the pterostigma; rest of details and hind wing as in fig. 147 and 148. Abdomen dark reddish-brown to black; first two basal tergites dorsally black, which extends into the basal half of third tergite; rest of abdomen reddish-brown; tergites nearly smooth and shiny except for silvery-brown setae, mostly disposed posterio-laterally; first two tergites much larger than others; rest of them gradually become shorter.

Holotype male, partly dissected on slide No. 121/B and rest on pin, labelled "Forest Zoologist. Coll., under stone, Dehra Dun, 24-1-1913."

Neodisepyris indicae, sp. nov.

Male.—Length 3.3 mm. Colour black. Head viewed from above length two-thirds the width; inter-orbital distance two-thirds the width of head; post-orbital distance slightly less than the width of eye; vertex broad, distinctly margined, rugoso-sculptured; eyes dark brown; sparsely pubescent; ocelli reddish-brown; interocellar distance a little over one and a half times the front ocellar and very slightly over half the ocellocular, which latter is thrice the front ocellar; viewed in front length very slightly less than the width; interorbital distance three-fifths the width of the head; length of eye four times that of gena and somewhat over one and a half times the postorbital distance; frons and face finely rugosely sculptured, with few scattered, shallow pits from which short brown pubescence are given off; clypeus depressed on either side with a raised median ridge; mandible reddish-brown, first tooth acute. Antennae brown; inserted below the middle of face on or just below an imaginary line joining the lower orbital borders; 13-jointed; scape one and two-thirds the pedicel and three-fourths the next two segments combined; first flagellar one and one-fifth the pedicel; second one and one-fourth the first; third and succeeding joints subequal, larger than second and very gradually become longer and then shorter (Fig. 155).

Thorax: Length two and a half times the width; pronotum one-fourth the whole length of thorax, finely rugosely sculptured; mesonotum three-fourths the pronotum, rugoso-coriaceously sculptured; parapsidal furrows nearly complete, anteriorly very fine and faint and posteriorly enlarging into foveae which do not touch the posterior border; scutellum slightly smaller than mesonotum, rugoso-carinately sculptured; metathorax one-fifth the scutellum, nearly smooth and shiny; propodeum slightly over one-third the whole length of thorax and equal to mesonotum, scutellum and metathorax combined; reticulately carinately sculptured, with five longitudinal carinae, one median longitudinal and four lateral, two on either side, which slightly converge posteriorly; all these longitudinal carinae meet the transverse carina that separates the anterior horizontal area from the posterior slanting part; posterior declivous area sculpture nearly same, but finer, the median longitudinal carina traversing the area to the very apex; lateral marginal and basal carinae also present. Legs dark reddish-brown. Fore coxa slightly less than twice the trochanter; femur slightly more than thrice the trochanter; tibia somewhat longer than femur; tibial spur very slightly more than one-third the tibia; metatarsus very slightly less than two-thirds the tibia and two-thirds the rest of tarsi combined (Fig. 158). Hind coxa twice the trochanter; femur nearly four times the trochanter; tibia one and one-eighth the femur; larger tibial spur approximately one-fourth the tibia and smaller two-thirds the larger; metatarsus slightly longer than half the tibia and four-fifths the rest of tarsi combined; tibia and tarsi beset with spinous setae especially the apices of tarsi; claw bifid, teeth acute, rest of details and setation as in fig. 156 and 157. Fore wing length slightly less than two and four-fifths the breadth; radius somewhat less than one-third the length of the wing; basal slightly over one-fourth the radial; transversal equal to basal; nearly hyaline; except slightly cloudy area around the radius; hind wing with four frenular hooks; rest of details and setation as in fig. 153 and 154. Abdomen dark reddish-brown, with lighter apex; nearly three-fifths the thorax; oval with apex nearly truncate; four tergites distinctly visible, first the largest; second and third slightly shorter; terminal one-fourth the penultimate; tergites smooth and shiny, except the anterior half of the third, which is finely coriaceously sculptured.

Holotype male, partly dissected on slide No. 98/B and rest on pin, labelled: "Pusa, Bengal, A. Murtaza, Nov. 1909."

Neodisepyris pusae, sp. nov.

Male.—Length 6.4 mm. Colour black with dark reddish-brown hue in the abdomen. Head viewed from above transverse, somewhat less than twice as broad as long; interorbital distance two-thirds the width of the head; vertex convex, irregularly rugosely punctate and sparsely pubescent; somewhat distinctly margined; ocelli reddish-brown, arranged in a triangle; interocellar one and a half times the front ocellar and slightly less than half the ocellocular, which latter is slightly less than four times the front ocellar; eyes large, brown, sparsely pubescent; viewed in front length somewhat equal to width; interorbital distance two-thirds the width; length of eye nearly five times that of gena; mandible strong, reddish-brown, with few setae; frons and face somewhat smooth, with uniformly scattered, shallow punctures, from which are given off, silvery-white pubescence with a coppery-tinge; clypeus depressed, dark reddish-brown, with apex rounded. Antennae inserted on two round knob-like projections, above the clypeus, on an imaginary line joining the lower orbital borders; reddish-brown; 13-jointed; scape two and a half times the pedicel; first flagellar five-sevenths the pedicel; second and remaining segments longer, subequal or gradually become shorter, except the last which is one and one-third the scape; terminal joint somewhat less than the two penultimate joints combined (Fig. 163 & 164).

Thorax two and a half times as long as broad; prothorax coriaceously sculptured, with few shallow, but broad pits, somewhat less than one-third the length of the whole of thorax; mesothorax sculpture nearly same as that of prothorax; slightly less than half the prothorax in length; parapsidal furrows complete, broadened and converging towards the posterior end; scutellum less than mesonotum, somewhat convex, with two deep pits laterally towards the anterior end; sculpture same as that of mesothorax, somewhat more than two-thirds the length of mesothorax; metathorax short; propodeum slightly longer than mesonotum, scutellum and metathorax combined; basal and lateral carinae present as also the demarcating carina between the horizontal and slanting areas; roughly irregularly sculptured; three longitudinal carinae, one median and two lateral; propodeal spiracles long, narrow and lanceolate. Fore coxa one and three-fourths the trochanter; femur three and a half times the trochanter; tibia two-thirds the femur; tibial spur one-third the tibia; metatarsus half the tibia and three-fourths the rest of tarsi combined (Fig. 162). Hind femur a little less than three and a half times the trochanter; tibia one and one-sixth the femur; tibial spur one-fourth the tibia; metatarsus somewhat less than half the tibia and three-fifths the rest of tarsi combined (Fig. 161 & 165). Fore wing length nearly thrice the breadth; radial two-sevenths the length of wing; basal nearly two-fifths the radial; transversal somewhat less than basal; hind wing with five frenular hooks (Fig. 159 & 160). Abdomen nearly as long as thorax, with six visible tergites; apex tapering; first tergite much longer than the others, rest gradually become shorter; apex of abdomen reddish-brown, with a golden-yellow lustre.

Holotype male, partly dissected on slide No. 73/B and rest on pin, labelled: "January 1907, Pusa, Bengal, A.M. coll."

Neodisepyris shishami, sp. nov.

Female.—Length 5.2 mm. colour black, with apex of abdomen reddish brown. Head viewed in front length equal to width; inter-orbital distance three-fourths the width of the head; length of eye three and a half times that of gena and nearly one and one-third the post-orbital distance; eyes black, bare or very sparsely pubescent; ocelli arranged in a nearly equilateral triangle; inter-ocellar distance one and one-fifth the front ocellar and very slightly less than one-fourth the ocellocular, which latter is five times the front ocellar; clypeus apex nearly rounded; mandible four dentate; first tooth acute, rest nearly blunt; covered over by silvery white pubescence. Antennae inserted just aboev the mouth on either side; 13-jointed, scape length twice the width, two and a half times the pedicel and one and a half times the pedicel and first flagellar combined; pedicel length one and a half times the width; first flagellar joint five-eighths the pedicel and one-fourth the scape; second slightly less than one and a half times the first; third and succeeding joints subequal, nearly same length as second, very gradually increase and then decrease in size; except the terminal, which is slightly less than twice the penultimate, a little more than half the scape and slightly more than one and one-third the pedicel; rest of details as in fig. 170.

Thorax: Length two and one-third the width; pronotum one-third the whole length of thorax, finely rugoso-coriaceously sculptured, with silvery-brown pubescence; mesonotum one-third the pronotum, sculpture nearly the same as in pronotum, but punctae more distinct; tegulae reddish-brown; parapsidal furrows distinct, deep and complete, posteriorly broadened; lateral to parapsidal furrows are distinct and deep lateral furrows; scutellum slightly longer than mesonotum, very finely rugosely sculptured or nearly smooth and shiny; metanotum nearly one-third the scutellum, irregularly roughly coriaceously sculptured; propodeum one and half times the mesonotum, scutellum and metathorax combined; reticulo-carinately sculptured in the anterior area and roughly rugosocarinate in posterior part; three parallel longitudinal carinae, one median and two lateral carinae other than the lateral marginal carinae; the median longitudinal carina runs right down through the posterior part to the very apex of the propodeum; lateral longitudinal carinae stop at the transverse carina demarcating the anterior horizontal area from the posterior declivous part; between the median and lateral carinae are two incomplete, branching, longitudinal carinae, which do not reach transverse carina; these parallel longitudinal carinae are interconnected by branching transverse carinae, giving the anterior part of propodeum a reticulately carinate appearance; the lateral marginal continue in posterior end of propodeum as basal carina. Legs reddish-brown; Fore coxa thrice the trochanter; femur five times the trochanter; tibia somewhat more than three-fourths the femur; tibial spur less than half the tibia; metatarsus half the tibia and three-fourths the rest of tarsi combined (Fig. 167). Hind coxa three and one-third the trochanter; femur five and one-third the trochanter; tibia somewhat longer than femur; tibial spur one-fourth the tibia; metatarsus slightly less than half the tibia and nearly three-fifths the rest of tarsi combined; rest of details and setation as in fig. 168 and 169. Fore wing length two and two-thirds the breadth; radial two-sevenths the length of the wing; basal slightly more than one-third the radial; transversal four-fifths the basal; prostigma short one-eighth the pterostigma; pterostigma length nearly four times the breadth, very slightly over half the radial; rest of details as in fig. 166. Abdomen black, basally constricted into a very short petiole; dark reddish-brown to black; seven tergites distinctly visible; first two tergites nearly smooth and shiny and with very few setae disposed laterally; rest of tergites also without any sculpture, with brown hair all over; last two tergites reddish-brown; first two tergites much larger than the others; rest of them gradually become shorter; ovipositor reddish-brown, nearly eight times the darker ovipositor-sheath.

Holotype female, partly dissected on slide No. 120/B and rest on pin, labelled: "For Zool. Coll., Shisham Bark, Dehra Dun, 22-1-1913."

Subfamily Pristocerinae

Pristocera govindrami Kurian

1952. *Pristocera govindrami*, KURIAN, *Agra Univ. J. Res.* (*Sci.*), 1 : 70-72.

To this species I refer No. 7/B recently described by me (*loc. cit.*)

Subfamily Bethylinae

KEY TO ORIENTAL SPECIES OF *Goniozus* FÖRSTER

1.	Head elongate, longer than broad	2
	Head not longer than broad	5
2.	Antennae and legs reddish-brown	3
	Antennae and legs lighter in colour	4
3.	Interocellar less than half the ocellocular; antennae reddish-brown; legs reddish-brown, with lighter tibiae and tarsi ...	*ahmeadi*, sp. nov.
	Interocellar more than half the ocellocular; antennae honey brown; legs reddish-brown with darker coxae and femora ...	*chatterjii*, sp. nov.
4.	Antennae and legs brownish-yellow	*philippinensis* Ashmead
	Antennae lemon-yellow; tibiae and tarsi yellowish-red ...	*borneanus* Cameron
5.	Propodeum without a triangularly raised, smooth and shiny area in the anterior part	6
	Propodeum with a triangular area	7
6.	Propodeum with three longitudinal carinae, median reaching the transverse carina separating the anterior and posterior areas	*hypsipylae*, sp. nov.
	Propodeum without three longitudinal carinae ...	8
7.	Posterior margin of propodeum distinctly margined ...	*depressus* Kieffer
	Posterior margin of propodeum scarcely visible ...	*manilensis* Kieffer
8.	Mesonotum without parapsidal furrows, transverse carina of propodeum absent	9
	Mesonotum with or without parapsidal furrows, transverse carina may or may not be present.	10
9.	Propodeum with a triangularly raised area much large and nearly reaching almost to the posterior margin and not connected by a longitudinal carina; legs yellow, femora brown ...	*triangulus* Kieffer
	Propodeum with a triangular area continuing posteriorly as a carina up to the posterior margin; legs mostly light yellow ...	*triangulifer* Kieffer
10.	Legs yellow, anterior femora in male pale brown; transverse carina in propodeum absent; mesonotum with parapsidal furrows	*williamsi* Bridwell
	Legs vary from yellow to reddish-brown; propodeum with a triangular area continuing as a carina which may or may not join the transverse carina defining the upper limit of propodeal declivity; mesonotum with or without parapsidal furrows ...	11
11.	Propodeum with transverse carina; head normal ...	12
	Propodeum with or without transverse carina; with an unusually smooth head	13

12. Radial one-fifth or more than one-fifth the length of wing ... *lygropiae*, sp. nov.
Radial less than one-fifth the length of wing ... 14
13. Eyes normal, transverse carina of propodeum present ... *fulvicornis* (Rohwer)
Eyes much smaller, transverse carina of propodeum absent or only a faint line present ... ... *indicus* Ashmead
14. Scape twice or more than twice the pedicel 15
Scape less than twice the pedicel 16
15. Propodeum with a distinct leathery sculpture; legs dark reddish-brown, with lighter tarsi; fore wing length two and a half times the breadth ... ... *nephoterycis* Kurian
Propodeum with fine coriaceous sculpture; legs reddish-brown; coxae and femora darker; fore wing length very slightly less than thrice the breadth ... ... *marasmi*, sp. nov.
Propodeum leathery-sculptured, legs yellow with a brownish tinge, fore wing length thrice the breadth ... ... *morindae* Kurian
16. Interocellar twice or more than twice the front ocellar ... 17
Interocellar less than twice the front ocellar ... ... *thalasodes*, sp. nov
17. Mesonotum with a median longitudinal groove ... *madrassippattanami*, sp. nov.
Mesonotum without median longitudinal groove ... 18
18. Parapsidal furrows or lateral furrows absent ... ... *sancti-johannis*, sp. nov.
Parapsidal furrows or lateral furrows present 19
19. Ocellocular thrice or more than thrice the front ocellar ... *choudhari*, sp. nov.
Ocellocular less than thrice the front ocellar ... 20
20. Interocellar distance equal to ocellocular ... ... *hybleae*, sp. nov.
Interocellar less than the ocellocular 21
21. Basal stalk of basal one-fifth the radial; antennae golden-yellowish-brown; propodeum irregularly rugoso-reticulately sculptured *mori*, sp. nov.
Basal stalk of basal one-sixth the radial; antennae honey-brown; propodeum rugoso-coriaceously sculptured with a leathery appearance ... ... *nilamburesis*, sp. nov.

Goniozus ahmeadi, sp. nov.

Male.—Length 4 mm. Colour dark reddish-brown. Head reddish-brown, length very slightly less than two-thirds the width; interorbital distance three-fourths the width of the head; vertex smooth and shiny, with few scattered pubescence, emarginate; eyes small, brown, bare; postorbital distance one and three-fourths the width of eye; ocelli arranged in a somewhat equilateral triangle; inter-ocellar distance two-fifths the ocellocular which latter is thrice the front ocellar; viewed in front length one and one-eighth the width; inter-orbital distance five-eighths the width of the head; length of eye thrice that of gena; postorbital very slightly over the length of eye; frons and face smooth and shiny; clypeus reddish-brown, with apical border darker, with a median longitudinal carina running to a level slightly above the insertion of the antennae; mandibles reddish-brown; 4-dentate, all teeth blunt, with stiff silvery-brown setae towards the base. Antennae reddish-brown, with a yellow tinge towards the base; inserted above the clypeus on either side, below the lower orbital borders; 13-

jointed; scape twice the pedicel; first flagellar four-fifths the pedicel, rest of flagellar joints gradually become shorter except the second which is as long as the penultimate; terminal nearly half the scape and same length as pedicel (Fig. 173).

Thorax: Length two and a half times the width at the region of tegulae; pronotum long, slightly over one-third the whole length of thorax, finely rugosely sculptured, with a coriaceous appearance in some places, posteriorly with spinous process on either side; mesonotum nearly half the pronotum, nearly smooth and shiny, with a faint coriaceous sculpture; parapsidal furrows distinct and complete; scutellum somewhat shorter than mesonotum, impunctate and shiny; metathorax very short; propodeum equal to mesonotum, scutellum and metathorax combined; finely coriaceously sculptured, with a slightly elevated, triangular, anterior area which continues nearly to the end of the anterior horizontal area of propodeum; anterior and posterior areas of propodeum not differentiated by a transverse carina, lateral and basal carina present; propodeal spiracles medium sized and oval. Legs reddish-brown, with a lighter tibia and tarsi. Fore coxa one and three-fourths the trochanter; femur very slightly longer than three and a half times the trochanter; tibia three-fourths the femur; tibial spur slightly shorter than one-fourth the tibia; metatarsus very slightly more than two-fifths the tibia; rest of tarsi combined one and one-third the metatarsus (Fig. 174). Hind coxa three times the trochanter; femur very slightly over five times the trochanter; tibia one and one-fifth the femur; larger tibial spur one-fourth the tibia and smaller slightly less than half the larger; metatarsus half the tibia and two-thirds the rest of tarsi combined (Fig. 175). Fore wing length thrice the breadth; radial one-fifth the length of the wing; basal stalk of basal nearly one-seventh the radial, anterior branch shorter than posterior the latter twice the common stalk; tranversal somewhat longer than the basal stalk of basal (Fig. 171 & 172). Abdomen long, lanceolate, with a short petiole; nearly one and half times the thorax; reddish-brown, basally somewhat lighter; dorsally arched six tergites distinctly visible, first two much larger than the rest; tergites smooth and shiny, with a few silvery-white setae transversely arranged towards the middle of tergites.

Holotype male, partly dissected on slide No. 26/B and rest on pin, labelled: "C. S. 223, from pupa in the burrow of stem borer, Cuttack, M. Ahmed coll. 18-9-1937, Imperial Entomologist 1938, Delhi, 869."

Goniozus chatterjii, sp. nov.

Female.—Length 2.4 mm. Colour black with dark reddish-brown abdomen. Head black; viewed from above length slightly more than half the width; inter-orbital distance three-fourths the width of the head; width of eye nearly twice the post-orbital distance; eyes black, bare; vertex rugosely sculptured, somewhat narrow and margined; ocelli dark reddish-brown, arranged in a broad triangle; interocellar distance nearly two-thirds ocellocular and twice the front ocellar; ocellocular nearly thrice the front ocellar; viewed in front length somewhat more than the width; interorbital distance slightly less than two-thirds the width of eye; length of eye nearly ten times that of gena and nearly four times the post-orbital distance; frons and face finely rugosely sculptured, with some shallow pits; clypeus dark reddish-brown to black, somewhat beak-like with a median longitudinal carina, which continue as a faint line up to a level of about one-third the length of eye, sparsely covered over by short silvery-white pubescence; mandible light reddish-brown, with darker teeth; 4-dentate, teeth short and acute. Antennae honey-brown; inserted on either side of the clypeus, just below an imaginary line joining the lower orbital borders; 13-jointed; scape length slightly less than twice the width, one and a half times the pedicel; pedicel length slightly over one and a half times the width; first flagellar slightly smaller than the pedicel; second slightly shorter; third and succeeding joint subequal, nearly equal to first and very gradually become shorter except the terminal, which is one and one-third the penultimate, two-thirds the scape and very slightly longer than the pedicel (Fig. 178).

Thorax: black, length one and three-fourths the breadth; pronotum large, rugosely sculptured, with fairly long silvery-white setae scattered; mesonotum three-fourths the pronotum, faintly rugoso-coriaceously sculptured anteriorly, posteriorly same sculpture as pronotum, setae silvery-white with a brownish tinge, irregularly scattered; parapsidal furrows complete, anteriorly faint; scutellum slightly more than half the mesonotum, same sculpture as posterior part of mesonotum, slightly smoother, with two oval foveae anterio-laterally placed; pubescence sparser and disposed mostly anteriorly and laterally; metathorax one-third the scutellum, faintly and finely sculptured, nearly smooth and shiny; propodeum equal to mesonotum, scutellum and metathorax combined, roughly rugoso-coriaceously sculptured with a leathery appearance; anteriorly with a smooth, shiny, triangular area, continuing as a smooth and raised line posteriorly, meeting the transverse carina that demarcates the anterior horizontal area from the posterior slanting part; propodeal spiracles lanceolate. Legs reddish-brown, with darker coxae and femora. Fore coxa nearly twice the trochanter; femur three and a half times the trochanter; tibia four-fifths the femur; tibial spur very slightly more than one-fourth the tibia; metatarsus slightly less than half the tibia and one and one-fourth the rest of tarsi combined (Fig. 181). Hind coxa twice the trochanter; femur nearly four times the trochanter; tibia slightly longer than the femur; tibial spur one-fourth the tibia; metatarsus four-sevenths the tibia and slightly less than four-fifths the rest of tarsi combined (Fig. 179 & 180). Fore wing length four times the breadth; prostigma length one and two-thirds the breadth; pterostigma length one and three-fourths the prostigma, length slightly over twice the width; radial somewhat longer than one-sixth the length of the wing; basal stalk of basal slightly more than one-fifth the length of radial; anterior branch of basal one and one-fifth the basal stalk and three-fourths the posterior branch; transversal four-fifths the basal stalk of basal and half the posterior branch of basal; rest of details and hind wing as in fig. 176 and 177. Abdomen dark reddish-brown to black, as long as thorax; six tergites distinctly visible; tergites nearly smooth and shiny, except for fine, faint transversely coriaceous sculpture in anterior parts of tergites and few short silvery-brown setae, mostly disposed posterio-laterally; ovipositor-sheath half the last tergite; ovipositor well exserted, five times as long as ovipositor-sheath.

Holotype female, No. 125/B and paratype females, No. 125/B and 119/B partly dissected on slides and rest on pin, labelled: "Dehra Dun, U.P. N.C. coll:, Parasitic on Pyralidae larvae defoliating mulberry, RRD 628, BCR 226, Chatterji Cage-B.J. 343, Ajabpur, 28-4-1949."

Goniozus chowdhari, sp. nov.

Male.—Length 2.7 mm. Colour dark reddish-brown to black. Head dark reddish-brown; viewed from above length half the width of the head, interorbital distance slightly over three-fifths the width of the head; width of eye slightly less than twice the post-orbital, eyes black, bare; ocelli reddish-brown, arranged in a broad triangle; interocellar distance slightly less than twice the front ocellar, which latter is very slightly over one-third the ocellocular, vertex rugosely sculptured, with very few irregularly scattered long silvery-brown setae, somewhat distinctly margined; viewed in front length somewhat less than the width; interorbital distance slightly less than two-thirds the width of the head; length of eye six times that of gena and two and a half times the post-orbital distance; frons and face distinctly and finely rugosely sculptured, with few scattered very shallow depressions from which fine silvery-brown setae are given off. Clypeus somewhat beak-like, with a dark broad tooth at apex and a median carina which runs up to nearly one-third the length of eye; mandibles light reddish-brown with darker teeth, 4-dentate, first tooth acute, rest blunt; distinctly covered over by short spinous setae. Antennae inserted on the clypeus on either side far below the middle, on an imaginary line joining the lower orbital borders; reddish-brown; 13-jointed; scape one and three-fourths the pedicel; first flagellar equal to pedicel; second and following joints nearly subequal except eighth, ninth and tenth which are slightly shorter than the preceding; terminal joint nearly one and a half times the penultimate, five-sevenths the scape and one and one-fourth the pedicel (Fig. 184).

Thorax: dark reddish-brown; length slightly less than twice the width at the region of the tegulae; prothorax nearly one-fourth the whole length of thorax, transversely coriaceously sculptured anteriorly and rugosely sculptured with a shagreened appearance posteriorly; mesonotum as long as pronotum, roughly coriaceously sculptured anteriorly and rugosely sculptured posteriorly; parapsidal furrows deep, distinct and complete; scutellum with a shagreened sculpture, two-thirds the mesothorax; metathorax with sculpture more irregular and fainter than in any other part of thorax, two-fifths the scutellum; propodeum slightly less than twice the scutellum and metathorax combined; transversely coriaceously sculptured with a somewhat shagreened appearance in certain angles, with a triangularly raised area anteriorly in the middle; lateral and basal carina present as also the transverse carina separating the anterior horizontal area from the posterior slanting part; propodeal spiracles large and lanceolate. Legs reddish-brown. Fore leg stout; coxa two and a half times the trochanter; femur five times the trochanter; tibia three-fourths the femur, femur swollen; tibial spur nearly one-third the tibia; metatarsus two-fifths the tibia and slightly less than three-fourths the rest of tarsi combined (Fig. 185). Hind coxa twice the trochanter; femur four times the trochanter; tibia very slightly longer than femur; tibial spur one-ninth the tibia and one-fifth the metatarsus; metatarsus slightly over half the tibia and two-thirds the rest of tarsi combined; claw bifid (Fig. 186 & 187). Fore wing length approximately thrice the width; radial very slightly less than one-fifth the length of the wing; basal stalk of basal one-fourth the radial, anterior branch of basal slightly longer than the basal stalk of basal and seven-eighths the posterior branch; rest of details and hind wing as in fig. 182. and 183. Abdomen black; dorsally arched, basally somewhat petiolate; nearly smooth and shiny, except for few scattered silvery-white setae in the anterior region of second tergite; posterior tergites transversely coriaceously striate at the bases; six tergites distinctly visible, first larger than the rest.

Holotype male, completely dissected on slides No. 91/B; paratype 2 males, 93/B completely dissected on slide and 80/B partly dissected on slide and rest on pin, all labelled; "Delhi, F.L. Chowdhary, 2 July 1938, parasitic on larvae, C.S. No. 3220, Imperial Entomologist."

Goniozus hybleae, sp. nov.

Female.—Length 2.0-3.0 mm. Colour black. Head viewed from above length nearly half the width; inter-orbital distance three-fourths the width of the head; width of eye twice the post-orbital distance; eyes black, bare; vertex narrow margined, finely rugosely sculptured; ocelli reddish-brown, arranged in a broad triangle; interocellar distance equal to ocellocular, which latter is twice front ocellar; viewed in front length slightly less than the width; interorbital distance somewhat more than half the width of the head; length of eye five times that of gena; frons and face finely rugoso-coriaceously sculptured, with few irregularly scattered silvery-brown setae; clypeus prominent, somewhat beak-like, with a carina medially running up to a level slightly more than one-third the length of eye, with few short, silvery-white pubescence; mandibles reddish-brown, 3-dentate, teeth small, first and second teeth acute, third blunt and broad, compared to the rest. Antennae reddish-brown with darker apex, inserted below the middle of eye, on an imaginary line joining the lower orbital borders and on either side of the clypeus lateral to the longitudinal carina; 13-jointed; scape length slightly less than twice the width; pedicel one and a half times the width; scape one and five-sixths the pedicel; first flagellar one and one-fifth the pedicel; second five-sixths the first; third and succeeding joints gradually become shorter, except the terminal which is one and four-sevenths the penultimate, four-sevenths the scape, and very slightly longer than the pedicel (Fig. 193).

Thorax black; length twice the width; pronotum somewhat large, rugoso-coriaceously sculptured, with a very faint median longitudinal elevation;

propleura roughly coriaceous; mesonotum somewhat shorter than pronotum; same sculpture as pronotum; tegulae dark reddish-brown; parapsidal furrows distinct and deep posteriorly, but finer and fainter anteriorly; mesopleura finely coriaceous; scutellum three-fourths the mesonotum, sculpture same as pro- and mesonotum, but finer, two small oval foveae anterio-laterally disposed; metathorax nearly one-third the scutellum, very finely coriaceously sculptured, with two somewhat large and round lateral foveae; metapleura same sculpture as mesopleura; propodeum nearly equal to mesonotum, scutellum and metathorax combined; roughly rugoso-coriaceously sculptured, anteriorly with a median and triangular smooth area, which continues as a carina to the transverse carina that demarcates the anterior horizontal area from the posterior slanting part; two very distinct lateral carinae run down the whole length of propodeum to the apex, posteriorly becoming the basal carina. Legs reddish-brown, coxae and femora darker. Fore coxa slightly less than twice the trochanter; femur nearly four times the trochanter; tibia four-fifths the femur; tibial spur slightly less than one-fourth the tibia and half the metatarsus; metatarsus somewhat less than half the tibia and a little more than three-fourths the rest of tarsi combined (Fig. 191). Hind coxa two and one-third the trochanter; femur four and two-thirds the trochanter; tibia very slightly shorter than femur; metatarsus slightly more than half the tibia and four-fifths the rest of tarsi combined; tibial spur one-fourth the tibia (Fig. 190 & 192). Fore wing length slightly over thrice the breadth; radial one-sixth the length of the wing; basal stalk of basal slightly over one-fourth the radial; anterior branch of basal equal to basal stalk; posterior one and half times the anterior; transversal very slightly more than three-fourths the anterior and approximately half the posterior; pro- and pterostigma distinct, prostigma length nearly one and one-third the breadth; pterostigma length nearly twice the breadth; one and two-thirds the prostigma; rest of details and hind wing as in fig. 188 and 189. Abdomen slightly longer than thorax, sessile; six tergites distinctly visible; first three much larger than the rest; tergites nearly smooth and shiny except for faint coriaceous sculpture towards the base of tergites and few silvery-white short pubescence arranged nearly posterio-laterally; ovipositor-sheath short; ovipositor nearly as long as the last abdominal tergite, reddish-brown.

Holotype female, partly dissected on slide No. 133/B and rest on pin; paratypes many females, on pin with same No. 133/B, all labelled: "Nilambur, Madras, Expt. No. 248, RRD 671, Parasitic on *Hyblaea puera*, 15-7-1939."

Goniozus hypsipylae, sp. nov.

Female.—Length 5.0 mm. Colour Black, with abdomen dark reddish-brown to black. Head viewed from above length somewhat less than half the width of the head; interorbital distance nearly two-thirds the width of the head; width of eye one and one-fourth the postorbital distance; eyes somewhat large and bulging, dark brown; vertex broad, emarginate, distinctly rugosely sculptured, with some large, broad and shallow punctae; ocelli brown, arranged in a nearly equilateral triangle; interocellar distance three-sevenths the ocellocular, which latter is very slightly over two and a half times the front ocellar; frons and face same sculpture as vertex; viewed in front length somewhat less than width, interorbital distance three-fifths the width of the head; length of eye five times that of gena; clypeus rugoso-coriaceously sculptured, medially raised into a sort of keel, the ridge of which continues back as a carina and then as a faint line up to a distance of about less than one-third the length of eye; mandibles strong, dark reddish-brown, with darker teeth. Antennae dark reddish-brown covered over by silvery-brown setae; inserted much below the middle of face, just above the mouth on either side of the clypeus; scape length two and two-thirds the width, slightly less than twice the pedicel; pedicel length twice the width; first flagellar equal to pedicel; second and third subequal and are slightly shorter than the first; succeeding joints gradually become shorter until the penultimate is nearly two-thirds the first flagellar; terminal one and one-third the penultimate, nearly half the scape and slightly shorter than the pedicel (Fig. 196)

Thorax black, length twice the width; pronotum long, anteriorly narrowed into a sort of neck, roughly distinctly rugosely sculptured, with a few shallow but broad punctae and silvery-brown setae; mesonotum three-fourths the pronotum, divided by a transverse smooth ridge at one-fourth the distance from the anterior end; anterior area finely rugoso-coriaceously sculptured, posterior with same sculpture as pronotum, large punctae irregularly scattered; parapsidal furrows distinct and complete, lateral furrows incomplete; scutellum slightly more than half the mesonotum; sculpture nearly same as mesonotum, but with very few large punctae, two large oval foveae anterio-laterally disposed, one on either side; metathorax one-fourth the scutellum, irregularly sculptured with two large oval foveae laterally on either side; propodeum irregularly reticulately carinate in the anterior horizontal area, which is demarcated from the rugoso-coriaceously sculptured posterior slanting area by a transverse carina; three parallel longitudinal carinae, one median and two lateral; median carina distinct, reach the transverse carina, lateral carinae branch irregularly before reaching transverse carina; lateral marginal carinae run the whole length of propodeum and in the posterior part become the basal carina, which is somewhat irregular and not very distinct. Legs dark reddish-brown. Fore coxa one and three-fourths the trochanter; femur slightly less than four times the trochanter; tibia a little longer than three-fourths the femur; tibial spur one-fifth the tibia; metatarsus somewhat less than two-thirds the tibia, nearly thrice the tibial spur and two and one-third the next two tarsi combined (Fig. 197). Hind coxa two and one-fourth the trochanter; femur five times the trochanter; tibia one and one-eighth the femur; tibial spur one-fifth the tibia; metatarsus nearly half the tibia and five-sixths the rest of tarsi combined; claw bifid (Fig. 198 & 199). Fore wing length slightly less than thrice the breadth; radius nearly one-sixth the length of the wing; basal two-thirds the radius; transversal slightly over half the basal; prostigma length one and two-thirds the breadth; pterostigma slightly over one and a half times the prostigma; length a little over one and a half times the breadth; radial very slightly over twice the pterostigma (Fig. 194 & 195). Abdomen dark reddish-brown to black; seven tergites distinctly visible; first tergite the largest, rest of them except the last two subequal and nearly four-fifths the first; sixth tergite two-thirds the first, seventh half of the last two tergites combined; tergites nearly smooth and shiny, except for faintly coriaceous sculpture in the anterior part of each tergite.

Holotype female, partly dissected on slide No. 117/B and rest on pin and paratype 1female partly dissected on slide No. 118/B and rest on pin both labelled: "New Forest, Dehra Dun, U.P., R.N. Mathur coll. RRD 159, BCR 222 Cage 17, Parasitic on *Hypsipyla robusta,* sack-bands *Cedrela toona*, 28-5-1937."

Goniozus indicus Ashmead

1903. *Goniozus indicus*, Ashmead, *Indian Mus. Notes*, 5(3) : 178-181.
1939. *Goniozus cuttackensis*, Lal, *Indian J. Ent.*, 1(2) : 51-52.
1940. *Goniozus indicus*, Muesebeck, *Proc. ent. soc. Washington*, 42(6) : 121.
1942. *Goniozus indicus*, Pruthi and Mani, *Mem. Indian Mus.*, 13 : 429.
1952. *Goniozus indicus*, Kurian, *Agra Univ. J. Res.* (*Sci.*), 1 : 67-68.
1954. *Goniozus indicus*, Kurian, *Agra Univ. J. Res.* (*Sci.*), 3(1) : 285.

To this species I refer 4 males No. 15/B, 16/B, 17/B and 18/B bred at Pusa, Bihar by C.S. Misra, on sugarcane borers.

Goniozus lygropiae, sp. nov.

Female.—Length 2.25-3.00 mm. Colour black. Head brownish-black; viewed from above length half the width; inter-orbital distance about three-fourths the width of the head; width of eye twice the postorbital distance; eyes brownish-black, bare; vertex finely rugosely sculptured, narrow, margined; ocelli reddish-brown, arranged in a broad triangle; interocellar distance nearly three-fifths the ocellocular, which latter is three and one-third the front ocellar; viewed in front length very slightly less than the width; interorbital distance somewhat more than half the width of the head; length of eye nearly nine times that of gena; frons and face rugosely sculptured with a roughly shagreened appearance, with few shallow pits and silvery-white setae with a brownish-tinge, scattered irregularly; clypeus same colour as rest of head, beak-like with a median longitudinal carina running up to a level of about one-fourth the length of eye; mandible reddish-brown. Antennae golden yellowish-brown; covered somewhat densely by short silvery-white pubescence, inserted below the lower orbital borders on either side of the clypeus; 13-jointed; scape slightly less than twice the pedicel; length twice the width, pedicel length slightly less than one and a half times the width; first flagellar very slightly more than the pedicel; second four-fifths the first; third and succeeding joints sub-equal; nearly equal to second, gradually increase and then decrease in size, except the terminal, which is one and four-sevenths the penultimate and five-sevenths the scape and one and one-fourth the pedicel (Fig. 202).

Thorax black, with a dark reddish-brown tinge; length one and three-fourths the width at the region of the tegulae; pronotum long, finely rugoso-coriaceously sculptured, with few shallow irregularly scattered pits and silvery-brown setae; mesonotum somewhat shorter than pronotum, sculpture and setation same as in latter; parapsidal furrows distinct and deep posteriorly and fainter anteriorly; on either side of parapsidal furrows are two oval foveae one on either side; tegulae reddish-brown; scutellum somewhat shorter than mesonotum, sculpture same as in pro- and mesonotum, but fainter, with pubescence sparser and disposed laterally and two oval pits anteriolaterally placed, metathorax one-fourth the scutellum, sculpture extremely fine or nearly smooth and shiny; propodeum slightly longer than mesonotum, scutellum and metathorax combined; rugoso-carinately sculptured, giving it a finely reticulately sculptured appearance; triangularly raised smooth and shiny anterior area continuing as an indistinct carina to the transverse carina that separates the anterior horizontal area from the posterior slanting part; lateral marginal carinae traverse the whole length of propodeum up to apex, posteriorly becoming the basal carina; propodeal spiracles lanceolate-oval. Legs dark reddish-brown. with lighter trochanters, tibiae and tarsi. Fore coxa somewhat less than twice the trochanter; femur nearly four times the trochanter; tibia slightly over two-thirds the femur; tibial spur slightly less than one-third the tibia; metatarsus a little more than half the tibia and six-sevenths the rest of tarsi combined (Fig. 205.). Hind coxa two and one-fourth the trochanter; femur nearly four and one-third the trochanter; tibia slightly longer than femur; tibial spur nearly one-fourth the tibia and slightly less than half the metatarsus; metatarsus slightly over half the tibia and three-fourths the rest of tarsi combined (Fig. 203 & 204). Fore wing length nearly thrice the breadth; prostigma length one and one-third the breadth; pterostigma one and three-fourths the prostigma, length two and one-fourth the breadth; radial one-fifth the length of the wing; basal stalk of basal one-sixth the radial; anterior branch of basal one and one-third the basal stalk and three-fourths the posterior; transversal equal to basal stalk; rest of details and hind wing as in fig. 200 and 201. Abdomen black, nearly as long as thorax; six tergites distinctly visible; first four much longer than the last two; ovipositor-sheath as long as the last tergite; ovipositor well exserted twice the length of the ovipositor-sheath; tergites nearly smooth and shiny, with few silvery-white setae, with a brownish tinge.

Holotype female, completely dissected on slide No. 131/B labelled: "C No. 72 and 73, Edacode, Nilambur, Madras, S.N. Chatterji, 6-7-1938, expt. 3056, parasitic on *Lygropia sp.*"; paratypes females, with same label and also No. 132/B 136/B labelled: "Nilambur Madras, 11-14-9-1939, expt. no. 537, parasite of *Lygropia sp.* ex. cocoon 7-9-1939" and "C. No. 32, 34, 35, Elengeri, Nilambur, Madras, S.N. Chatterji, 27-6-1938, parasitic on *Lygropia sp.*"

Goniozus madrassippattanami, sp. nov.

Male.—Length 2.0-2.6 mm. Colour black, with dark reddish-brown to black abdomen. Head viewed from above transverse, length nearly half he whoe dhtittf head; postorbital distance slightly less than one-fourth the width of eye; eyes black, bare; ocelli large, reddish-brown, arranged in a broad triangle; interocellar distance two and one fourth the front ocellar and two and two-thirds the ocellocular, which latter is slightly less than the front ocellar; vertex smooth and shiny, faintly margined; viewed in front length seven-eighths the width; interorbital distance slightly less than half the width of the head; length of eye nearly nine times that of gena; postorbital distance nearly one-fifth the length of eye; clypeus black, apex nearly rounded, with a median longitudinal carina running up to about one-fourth the length of eye; frons and face smooth, with few scattered silvery-brown pubescence; mandibles reddish-brown. Antennae light reddish-brown, pubescent, beaded; inserted below the middle of face, below the lower orbital borders, on the clypeus; 13-jointed; scape one and a half times the pedicel; first flagellar as long as the pedicel; rest of flagellar joints gradually become shorter, except the terminal which is one and half times the penultimate, five-sevenths the scape and slightly longer than the pedicel (Fig. 208).

Thorax: Length somewhat less than twice the width; pronotum somewhat less than one-fourth the whole length of thorax, coriaceously sculptured; mesonotum very slightly longer than pronotum, faintly coriaceously sculptured; parapsidal furrows present as also a faint median longitudinal impression; scutellum equal to pronotum, nearly smooth and shiny; metathorax somewhat depressed, smooth and shiny; propodeum twice the scutellum, coriaceously sculptured; a triangular smooth, raised area in the anterior region, which continues posteriorly as a carina meeting the faint transverse carina separating the anterior horizontal area from the posterior slanting part, lateral and basal carina present; propodeal spiracles large, lanceolate-oval. Legs reddish-brown with lighter trochanters, tibiae and tarsi. Fore coxa two and two-sevenths the trochanter; femur much swollen, very slightly less than four times the trochanter; tibia slightly more than three-fourths the femur; tibial spur a little shoree than one-third the tibia; metatarsus somewhat less than half the tibia and thret-fourths the rest of tarsi combined (Fig. 209). Hind coxa slightly less than twice the trochanter; femur four times the trochanter; tibia nearly equal to femur; tibial spur one-fourth the tibia; metatarsus half the tibia and equal to the next three tarsi combined (Fig. 210). Fore wing length nearly thrice the breadth; radial slightly longer than one-sixth the length of the wing; basal stalk of basal somewhat less than one-third the radial; anterior branch of basal equal to basal stalk of basal; posterior nearly one and one-third the anterior, transversal six-sevenths the basal stalk of basal (Fig. 206 & 207). Abdomen nearly as long as thorax; dark reddish-brown to black, dorsally slightly arched, with a very short petiole; six tergites distinctly visible; first the largest and the rest gradually become shorter; tergites nearly smooth and shiny; except third which is faintly coriaceously sculptured; apical tergites distinctly covered over by silvery-brown pubescence.

Holotype male; wholly dissected on slide No. 123/B and paratypes males on pin, labelled: "Nilambur, Madras, A.H. Khan, 1939, RRD 598, parasitic on *Hapalia machaeralis.*"

Goniozus marasmi, sp. nov.

Female.—Length 2.5-3.0 mm. Colour dark reddish-brown to black. Head dark reddish-brown; viewed from above somewhat transverse, length very slightly over half the width of the head; interorbital distance slightly more than two-thirds the width of the head; width of eye two and a half times the postorbital distance; vertex finely rugosely punctured with a shagreened appearance, indistinctly margined; eyes brownish-black, bare; ocelli reddish-brown, large, arranged in a somewhat broad triangle; interocellar distance very slightly more than three-fifths the ocellocular, which latter is two and two-thirds the front ocellar; viewed in front length equal to width; inter-orbital distance nearly two-thirds the width of the head; length of eye nearly four and a half times that of gena and slightly over thrice the postorbital; frons and face finely rugosely punctate, with very few shallow scattered pits from which short hairs are given off; clypeus dark reddish-brown, with black and somewhat beak-like apex, with a median longitudinal carina running upto a level of about one-fourth the length of eye; mandible reddish-brown, 4-dentate; teeth same colour as the rest of mandible; clypeus and mandibles covered over by thin short silvery-white pubescence. Antennae reddish-brown, covered over by short, silvery-brown pubescence; inserted far below the middle of face, just on an imaginary line joining the lower orbital borders; 13-jointed; scape twice the pedicel; first flagellar one and one-fourth the pedicel; rest of them subequal and very gradually become shorter, except the terminal which is one and one-third the penultimate, which latter is equal to the pedicel; terminal very slightly less than three-fourths the scape; third and rest of flagellar segments have a beaded appearance (Fig. 213).

Thorax: Length two and one-sixth the width; prothorax nearly one-third the whole length of thorax, finely rugosely sculptured with faint coriaceous appearance; mesothorax slightly more than one-third the pronotum; sculpture nearly same as that of pronotum; parapsidal furrows distinct and complete; scutellum one and half times the mesonotum, sculpture nearly same as that of pronotum; metathorax very short; propodeum long, very slightly over twice the scutellum and metathorax combined, finely coriaceously sculptured; anterior median area of propodeum triangularly raised and continue as a longitudinal carina upto the transverse carina that separates the anterior horizontal area from the posterior slanting part, the carina being not very distinct in the middle; lateral marginal and basal carinae present; propodeal spiracles large, lanceolate. Fore coxa two and one-fourth the trochanter; femur three and a half times the trochanter; tibia three-fourths the femur; tibial spur slightly less than one-third the tibia; metatarsus slightly less than half the tibia and three-fourths the rest of tarsi combined (Fig. 214). Hind coxa very slightly less than two and a half times the trochanter; femur approximately four times the trochanter; tibia slightly longer than femur; tibial spur slightly less than one-third the tibia; metatarsus somewhat over half the tibia and nearly two-thirds the rest of tarsi combined (Fig. 215). Fore wing length slightly less than thrice the breadth; radial nearly one-sixth the length of the wing; basal stalk of basal nearly one-fourth the radial; anterior branch of basal one and a half times the basal stalk; posterior one and one-fourth the anterior; transversal slightly less than the basal stalk of basal; rest of details and hind wing as in fig. 211 and 212. Abdomen as long as thorax; dorsally somewhat arched, apex acuminate, basally constricted, petiole not clear; tergites nearly smooth and shiny with very few scattered, thin, silvery-white pubescence; seven tergites distinctly visible; second tergite the largest, last one very short.

Holotype female, completely dissected on slide No. 95/B and paratypes females, partly dissected on slide No. 34/B and rest on pin, both labelled: "Parasitic on *Marasmia trapezalis*, Pusa, Bihar, 6-10-1907."

Goniozus mori, sp. nov.

Female.—Length 2.8-2.9 mm. Colour black, with dark reddish-brown to black abdomen. Head black; viewed from above length somewhat less than half the width of the head; interorbital distance three-fourths the width of the head; width of eye somewhat less than twice the post-orbital distance; eyes brownish-black, bare; vertex finely rugoso-coriaceously sculptured, narrow, margined, with very few silvery-brown setae irregularly scattered; ocelli dark reddish-brown; interocellar distance twice the front ocellar and somewhat more than two-thirds the ocellocular, which latter is two and three-fourths the front ocellar; viewed in front length equal to width; interorbital distance three-fifths the width of the head; length of eye nearly ten times that of gena; frons and face finely rugosely sculptured, with few irregularly scattered greyish-brown setae; clypeus somewhat beak-like, apically rounded, with a median longitudinal elevation running as a carina upto a level slightly above the lower orbital borders; mandibles reddish-brown, with slightly darker teeth. Antennae golden yellowish-brown, covered over by silvery-brown pubescence, on either side of the clypeus, inserted below the lower orbital borders; 13-jointed; scape length sightly over twice the width, sightly more than one and a half times the pedicel; pedicel length one and two-thirds the width; first flagellar slightly more than four-fifths the pedicel; second and succeeding joints subequal, nearly equal to first, very gradually increase and then decrease except the terminal, which is one and three-sevenths the penultimate (Fig. 221).

Thorax black, with a dark reddish-brown tinge in a few places; length one and three-fourths the width; pronotum large, roughly rugosely sculptured, with few shallow pits and a few silvery-brown setae anteriorly and laterally disposed; mesonotum slightly over two-thirds the pronotum, nearly the same sculpture as pronotum, but pubescence sparser; parapsidal furrows complete but fainter anteriorly; scutellum slightly shorter than mesonotum, somewhat convex, almost the same sculpture as pro and mesonotum, with two small, elongately oval foveae anterio-laterally placed; metathorax one-fifth the scutellum; propodeum equal to mesonotum, scutellum and metathorax combined; anteriorly a smooth and shiny triangularly raised area, which continue posteriorly as a faint smooth raised line to transverse carina that separates the anterior horizontal area from the posterior slanting part; lateral carina traverses the whole length of propodeum right upto the apex, posteriorly running as the basal carina; irregularly rugoso-reticulately sculptured; propodeal spiracles lanceolate-oval. Legs reddish-brown, with darker coxae, trochanters and femora. Fore coxa slightly less than two and a half times the trochanter; femur four times the trochanter; tibia four-fifths the femur; tibial spur slightly less than one-fourth the tibia and slightly more than half the metatarsus; metatarsus two-fifths the tibia and five-sixths the rest of tarsi combined (Fig. 220). Hind coxa slightly more than twice the trochanter; femur somewhat less than five times the trochanter; tibia a little shorter than femur; tibial spur one-fourth the tibia and nearly half the metatarsus; metatarsus somewhat more than half the tibia and two-thirds the rest of tarsi combined (Fig. 218 & 219). Fore wing length thrice the width; prostigma length one and half times the width; pterostigma one and a half times the prostigma, length twice the breadth; radial somewhat less than one-fifth the length of the wing; basal stalk of basal slightly more than one-fifth the radial and equal to its own anterior branch, which latter is slightly more than half the posterior branch; rest of details and hind wing as in fig. 216 and 217. Abdomen as long as thorax, dark reddish-brown to black; six tergites distinctly visible; first four tergites much longer than the last two; ovipositor sheath half the last tergite, ovipositor reddish-brown, one and a half times the ovipositor-sheath; terigtes smooth and shiny, with few silvery-brown setae posterio-laterally disposed.

Holotype: female, partly dissected and mounted on slide No. 126/B and rest on pin; paratype 1 female, both labelled: '"New Forest, Dehra Dun, U.P., 19-5-1940, B.M. Bhatia coll. Cocoon collected on *Morus indica* leaves, D-45."

Goniozus morindae Kurian

1952. *Goniozus morindae*, KURIAN. *Agra Univ. J. Res.* (*Sci.*), 1 : 66-67.
1954. *Goniozus morindae*, KURIAN, *Agra Univ. J. Res.* (*Sci.*), 3(1) : 285.

To this species I refer No. 139/B recently described by me (*loc. cit.*).

Geniozus nephoterycis Kurian

1952. *Goniozus nephoterycis*, KURIAN, *Agra Univ. J. Res.* (*Sci.*), 1 : 63-65.
1954. *Goniozus nephoterycis*, KURIAN, *Agra Univ. J. Res.* (*Sci.*), 3(1) : 285.

To this species I refer No. 1/B recently described by me (*loc. cit.*).

Goniozus nilamburensis, sp. nov.

Female.—Length 2.75-2.90 mm. Colour dark reddish-brown. Head viewed from above length very slightly more than two-fifths the width; interorbital distance three-fifths the width of the head; width of eye two and three-fourths the post-orbital; eyes dark brown, bare vertex finely rugoso-coriaceously sculptured; distinctly margined; the carina running transversely behind the posterior ocelli and nearly contiguous with them; ocelli dark reddish-brown;

interocellar distance twice the front ocellar and four-fifths the ocellocular, which latter is two and a half times the front ocellar; viewed in front length slightly less than the width; interorbital distance nearly three-fifths the width of the head; inner orbital borders somewhat diverging above, length of eye six times that of gena; frons and face finely rugosely sculptured with a finely leathery appearance and few shallow punctae and few thin scattered silvery-white setae; clypeus dark reddish-brown, medially apically raised conically, somewhat beak-like, with a medially raised longitudinal ridge continuing as a carina upto one-third the length of eye and then disappear; mandibles dark reddish-brown. Antennae honey-brown; inserted below an imaginary line joining the lower orbital borders; just above the clypeus; 13-jointed; scape one and three-fifths the pedicel; first flagellar four-fifths the scape; second and following flagellar joints subequal, nearly equal to first, very gradually increase and then decrease in size, except the terminal which is one and one-third the penultimate, somewhat longer than the pedicel and nearly three-fourths the scape (Fig. 223).

Thorax: Length one and three-fourths the width at the region of the tegulae; pronotum rugoso-coriaceously sculptured, with few scattered silvery-white setae; mesonotum one and one-third the pronotum, sculpture nearly same as pronotum, with few shallow pits from which setae are given off; parapsidal furrows distinct and complete; scutellum nearly flat, somewhat shorter than mesonotum, with few small oval foveae anterio-laterally placed and very few larger setae laterally disposed; metathorax one-fourth the scutellum; propodeum equal to pro and mesonotum combined and about twice the scutellum; rugoso-coriaceously sculptured, with a leathery appearance, with an anterior median triangular smooth area continuing posteriorly as a faint smooth line or carina which joins the transverse carina that separates the anterior horizontal area from the posterior slanting part; lateral marginal carinae run down the whole length of propodeum and posteriorly continue as the basal carina; propodeal spiracles medium sized and leniar. Fore femur four and two-thirds the trochanter; tibia five-sevenths the femur; tibial-spur one-fourth the tibia; metatarsus slightly over two-fifths the tibia and five-sixths the rest of tarsi combined (Fig. 225). Hind femur four and a half times the trochanter; tibia equal to femur; tibial spur approximately one-fourth the tibia; metatarsus somewhat over half the tibia and four-fifths the rest of tarsi combined (Fig. 224 & 226). Fore wing length nearly thrice the breadth; radial very slightly less than one-fifth the length of wing; basal stalk of basal slightly more than one-sixth the radius; anterior branch of basal one and one-third the basal stalk; posterior branch very slightly over one and a half times the anterior; transversal equal to basal stalk (Fig. 222). Abdomen dark reddish-brown, one and one-fourth the thorax; tergites nearly smooth and shiny; six tergites distinctly visible; first tergite slightly smaller than second; third and rest of tergites gradually become shorter; ovipositor-sheath slightly longer than the last tergite.

Holotype female, partly dissected on slide No. 134/B and rest on pin; paratypes many females, on pin No. 134/B and 135/B, all labelled: "Nilambur, Madras, 28-30-8-1939, RRD 710, *P. lacca* sp. and 25-30-8-1939, RRD 710, expt. No. 450."

Goniozus sancti-johannis, sp. nov.

Female.—Length 3 mm. Dark reddish-brown to black; shiny. Head viewed in front nearly round, slightly convex, sparsely punctate, pubescent, leathery; clypeus with a longitudinal carina running upto nearly one-third the eye level; mandibles reddish-brown, palpi yellow; eyes large and bare; two times as long as the postorbital length; ocelli distinct, brown, arranged in a broad triangle; interocellar distance twice the front ocellar and three-fifths the ocellocular, which latter is three and one-third the front ocellar; front ocellus placed in a slight depression and hind ocelli placed in the posterior margin of head; vertex margined. Antennae reddish-brown, distal end darker, somewhat longer than the head; scape thick, one and three-fifths the pedicel, slightly shorter than the pedicel and first flagellar combined, longer than thick, nearly cylindrical; flagellar joints one to six serrate, rest of them oval; terminal joint one and two-thirds the penultimate, five-sevenths the scape and slightly longer than the penultimate (Fig. 230).

Thorax long, leathery in sculpture, with scattered shallow punctae; pronotum longer than mesonotum, microscopically shagreened; mesonotum nearly of the same length as that of scutellum; parapsidal furrows absent; scutellum shiny; propodeum finely reticulate with irregular lines at the sides, margined behind and at the sides; posterior declivous area also distinctly margined; medial area smooth and shiny, with a triangularly elevated area in anterior half which continues as a faint carina in the hind margin. Legs dark reddish-brown to black, except the honey-yellow fore tibia and yellowish-brown tarsi of all the legs. Fore coxa slightly less than twice the trochanter; femur two and one-third the trochanter; tibia nearly three-fourths the femur; tibial spur slightly less than one-third the tibia; metatarsus slightly less than half the tibia and three-fourths the rest of tarsi combined (Fig. 231). Hind coxa nearly twice the trochanter; femur nearly four times the trochanter; tibia slightly longer than the femur; tibial spur slightly shorter than one-third the tibia; metatarsus slightly shorter than half the tibia and nearly four-sevenths the rest of tarsi combined; claw bifid (Fig. 229). Fore wing length two and three-fourths the breadth; radial vein slightly shorter than one-fifth the whole length of wing and nearly equal to pro and pterostigma combined; pterostigma nearly one and two-thirds the prostigma; basal stalk of basal nearly one-fourth the radial and five-sevenths its anterior branch, which latter is equal to posterior branch of basal; the whole of basal is nearly twice the transversal; veins yellowish-brown, pro- and pterostigma dark brown; costa and subcosta confluent; rest of details and hind wing as in fig. 227 and 228. Abdomen smooth and shiny, anteriorly with an impression, slightly dorsally arched.

Holotype female, partly dissected on slide No. 21/B and rest on pin, labelled: "On wing, St. John's College, Agra; Chandy Kurian Coll., 10-3-1950."

Goniozus thalasodi, sp. nov.

Male.—Length 1.8 mm. Colour dark reddish-brown. Head viewed from above length slightly over two-fifths the width; inter-orbital distance somewhat more than two-thirds the width of the head; postorbital very slightly less than half the width of eye; vertex rugosely sculptured, emarginate; eyes brownish-black, bare; length of eye two and a half times that of postorbital distance; ocelli arranged in a somewhat broad triangle; interocellar distance slightly over one and a half times the front ocellar and slightly less than the ocellocular, which latter is one and three-fourths the front ocellar; viewed in front length equal to width; interorbital distance somewhat more than half the width of the head; postorbital distance nearly half the length of eye; length of eye nearly four times that of gena; frons and face finely rugosely sculptured, with a somewhat shagreened appearance; clypeus reddish-brown, conical with a carina running upto a level of about one-third the length of eye from below; mandibles light reddish-brown. Antennae reddish-brown; inserted just above the clypeus, below an imaginary line joining the lower orbital borders; beaded and with short, stiff, light brown setae; 13-jointed; scape one and two-thirds the pedicel; first flagellar equal to pedicel; rest of flagellar joints subequal and are equal to first; terminal joint one and half times the penultimate, slightly less than the scape and one and a half times the pedicel (Fig. 232).

Thorax reddish-brown, length one and two-thirds the width; pronotum slightly less than one-sixth the whole length of thorax, rugosely sculptured, with a coriaceously sculptured appearance in some places; mesonotum one and one-fourth the pronotum; sculpture nearly same as pronotum; parapsidal furrows distinct and complete; scutellum very slightly shorter than mesonotum, sculpture almost same as in pro- and mesonotum, but somewhat finer; metathorax slightly less than half the scutellum, nearly smooth and shiny; propodeum two-fifths the whole length of thorax, rugosely sculptured, lateral marginal and basal carinae present, as also the transverse carina separating the anterior horizontal area from the posterior slanting part; anterior area with a smooth, shiny, triangularly raised area joining the transverse carina by a longitudinal carina; propodeal spiracles large and elongate-oval. Legs reddish-brown, lighter than the rest of the body. Fore coxa somewhat over twice the trochanter, femur four times the trochanter; tibia slightly more than three-fourths the femur; tibial spur very slightly more than one-fifth the tibia; metatarsus half the tibia and seven-eighths the rest of tarsi combined (Fig. 234). Hind coxa one and four-fifths the trochanter; femur nearly four times the trochanter; tibia same length as femur; tibial spur slightly less than one-third the tibia; metatarsus four-sevenths the tibia and two-thirds the rest of tarsi combined (Fig. 235 & 236). Fore wing length slightly less than thrice the breadth; radius one-sixth the length of the wing; basal stalk of basal slightly less than one-third the radius; anterior branch of basal four-fifths the basal stalk and very slightly more than half the posterior branch; transversal two-thirds the basal stalk of basal (Fig. 233). Abdomen petiolate, very slightly longer or nearly equal to thorax, somewhat dorsoventrally flattened; five tergites distinctly visible; first tergite half the whole length of abdomen.

Holotype female, partly dissected on slide No. 52/B and rest on pin, labelled: "Parasitic on *Thalasodes vevaria* on litchi leaves, Pusa, 17-1-1921."

Trissomalus indicus Kurian

1954. *Trissomalus indicus*, Kurian, *Agra Univ. J. Res.* (*Sci.*), 3(2) : 426-429.

To this species I refer No. 141/B recently described by me (*loc. cit.*) This genus[1] was recorded for the first time from Oriental region.

Perisierola pulveriae Kurian

1954. *Perisierola pulveriae*, Kurian, *Agra Univ. J. Res.* (*Sci.*), 3(2) : 429-433.

To this species I refer No. 143/B and 144/B recently described by me (*loc. cit.*).

Perisierola salvadorae Kurian

1954. *Perisierola salvadorae*, Kurian, *Agra Univ. J. Res.* (*Sci.*), 3(2) : 433-436.

To this species I refer No. 148/B recently described by me (*loc. cit.*).

KEY TO INDIAN SPECIES of *Odontepyris* KIEFFER

1. Thorax length twice the width at the region of tegulae; fore wing length thrice the width; ocellocular thrice the front ocellar ... *cirphi*, sp. nov.
Thorax length more than two and one-third the width; fore wing lengthmore than thrice the breadth; ocellocular more than three and a half times the front ocellar 2
2. Interocellar very slightly more than the front ocellar; radial one-sixth the length of the wing; hind metatarsus half the tibia and five-sixths the rest of tarsi combined ... ... *argyriae* Kurian
Interocellar equal to front ocellar; radial one-fifth the length of the wing; hind metatarsus slightly less than half the tibia and very slightly over three-fourths the rest of tarsi combined ... *batrai*, sp. nov.

Odontepyris argyriae Kurian

1954. *Odontepyris argyriae*, Kurian, *Agra Univ. J. Res.* (*Sci.*), 3(2) p:p. 437-439.

To this species I refer No. 138/B recently described by me (*loc. cit.*).

Odontepyris batrae, sp. nov.

Female.—Length 5.2-6.5 mm. Colour black with reddish-brown legs. Head viewed from above transverse; length slightly less than two-fifths the width; inter-orbital distance three-fifths the width of the head; post-orbital slightly less than the width of eye; eyes dark brown; bare; vertex narrow, emarginate; irregularly rugoso-coriaceously sculptured, with few setae mostly laterally disposed; ocelli reddish-yellowish-brown, arranged in a nearly equilateral triangle; interocellar space one-third the ocellocular, which latter is three and a half times the front ocellar; between the ocelli finely rugosely sculptured; viewed in front length nearly seven-eighths the width; interorbital space nearly two-thirds the width of the head; length of eye three and two-fifths that of gena; frons rugosely punctate, with few irregularly scattered pits from which short silvery-brown setae are given off; face finely rugosely punctate with few, shallow, broad and scattered pits and few short silvery-brown setae, with a median longitudinal groove running down and joining the clypeal carina; clypeus rugulosely sculptured, prolonged into a beak-like structure with a carina running upto a level just above the insertion of antennae, below the lower orbital borders; mandible dark reddish-brown, 4-dentate, first two teeth acute, rest blunt. Antennae reddish-brown; 13-jointed; inserted below the middle of face, slightly below an imaginary line joining the lower orbital borders, just above the clypeus, laterally inserted; scape two and one-fifth the pedicel; first flagellar one and two-fifths the pedicel; second very slightly over three-fourths the first; rest of flagellar joints gradually become shorter; second to fifth subequal; sixth to eighth nearly equal, slightly shorter than previous ones; ninth and tenth shorter than the preceding; terminal one and one-fourth the preceding, slightly more than half the scape and nearly one and one-fifth the pedicel; rest of details as in fig. 239.

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[1] 1898. *Goniozus*, Buysson, *Ann. Soc. ent. France*, 66 : 354.
1905. *Trissomalus*, Kieffer, *Ann. Soc. Sci. Bruxelles*, 29 : 105.

Thorax: Length two and one-third the width; pronotum nearly one-third the whole length of thorax, finely rugosely sculptured with a shagreened appearance; mesonotum three-fifths the pronotum, sculpture same as in latter; parapsidal furrows deep, distinct and complete; scutellum two-thirds the mesonotum; sculpture same as in latter, but finer; metathorax short; propodeum with three longitudinal carinae, a very distinct median and two somewhat faint laterals; median carina joins the transverse carina separating the anterior horizontal area from the posterior slanting part; area between these longitudinal carinae are traversed by anastomosing transverse carinae giving the whole a reticulately sculptured appearance; lateral to these carinae, rest of propodeum rugosc-carinately sculptured, giving a somewhat shagreened appearance; the slanting posterior aspect of propodeum is finer and shagreened; propodeal spiracles large, lanceolate, anterior to spiracle is a deep reniform pit, which is anteriorly bounded by the raised paraspiracular carina. Legs reddish-brown; fore coxa two and two-thirds the trochanter; femur slightly over four times the trochanter; tibia four-fifths the femur; tibial spur slightly less than one-third the tibia; metatarsus half the tibia and three-fourths the rest of tarsi combined (Fig. 240. Hind coxa slightly less than thrice the trochanter; femur five times the trochanter; tibia one and one-fifth the femur; tibial spur one-sixth the tibia; matatarsus slightly less than half the tibia and very slightly over three-fourths the rest of tarsi combined; claw bifid, rest of details and setation as in fig. 241 and 242). Fore wing length three and one-eighth the breadth; radial nearly one-fifth the length of wing; basal somewhat more than one-third the radial;

transversal nearly two-thirds the basal; pterostigma length one and two-thirds the breadth; radial nearly straight for a long distance, apex curved; hyaline except for a faintly dusky area around the radius; hind wing with five frenular; hooks, rest of details as in fig. 237 and 238. Abdomen nearly as long as thorax dorsally somewhat convex, apically bent and pointed, basally constricted; petiole very short; seven tergites distinctly visible; first the largest, rest of them gradually become shorter, until the last one is nearly twice the ovipositor-sheath; tergites nearly smooth and shiny, except the third one which is somewhat shagreened anteriorly.

Holotype female partly dissected on slide No. 85/B and rest on pin; pratypes 3 Female partly dissected on slides and rest on pins, all labelled; "Bethylid parasite, Pusa, Bihar, H.N. Batra, 18-4-1934."

Odontepyris cirphi, sp. nov.

Female.—Length 4 mm. Colour black. Head dark reddish-brown to black; nearly prognathous; viewed from above transverse, constricted in the middle; interorbital distance two-thirds the width of the head; width of eye one and three-fourths post-orbital distance; vertex convex, emarginate; finely rugosely sculptured, with few large shallow punctae and few large silvery-white setae; ocelli reddish-brown, arranged in a nearly equilateral triangle; interocellar a little longer than the front ocellar and very slightly more than one-third the ocellocular, which latter is thrice the front ocellar; viewed in front length six-sevenths the width; inter-orbital distance nearly two-thirds the width of the head; frons and face sculptured as on vertex; length of eye nearly thrice that of gena; eyes blackish-brown and bare; mandible strong, reddish-brown, with acute teeth; clypeus prolonged, beak-like, with a median ridge running as a carina upto a level about a little above the lower orbital borders. Antennae reddish-brown; inserted far below the middle of face, below an imaginary line joining the lower orbital borders, just above the clypeus, on either side; 13-jointed scape nearly twice the pedicel; first flagellar one and one-eighth the pedicel; second very slightly shorter than first; rest of flagellar joints subequal or very gradually become shorter; terminal nearly one and one-third the penultimate, same length as first flagellar, three-fifths the scape and slightly longer than the pedicel (Fig. 246).

Thorax: Length twice the width at the region of tegulae; pronotum one and half times longer than mesonotum and nearly equal to mesonotum and scutellum combined, sculpture same as that of head; mesonotum sculpture same as that of pronotum; parapsidal furrows complete; mesopleura with a tooth-like projection on either side; scutellum slightly convex, nearly smooth and shiny, except for few large punctae; metathorax narrow, irregularly sculptured; propodeum nearly twice the scutellum and metathorax combined, with a median longitudinal carina, running upto the basal transverse carina differentiating the anterior horizontal area from the posterior declivous part; many irregular reticulate carination, giving the propodeum a roughly leathery sculpture;

propodeal spiracles large and lanceolate. Legs reddish-brown. Fore coxa slightly over twice the trochanter; femur over four times the trochanter; tibia five-sixths the femur; tibial spur somewhat less than one-third the tibia; metatarsus half the tibia (Fig. 247). Hind coxa three times the trochanter; femur seven times the trochanter; tibia somewhat longer than femur; tibial spur one-fifth the tibia; metatarsus slightly less than half the tibia and a little more than two-thirds the rest of tarsi combined; claw bifid (Fig. 245 & 248). Fore wing length thrice the breadth; hyaline except for slightly dusky area around radius. Radius very slightly less than one-sixth the length of the wing; very finely curved basally and somewhat abruptly apically; basal somewhat less than half the radius; transversal nearly four-fifths the basal; pterostigma length nearly one and one-third the breadth; radius arising from apex of pterostigma; rest of details and hind wings as in fig. 243 and 244. Abdomen one and one-fourth the length of thorax; dark reddish-brown; dorsally arched, apically pointed; basally constricted into a very short petiole; seven tergites visible; nearly smooth and shiny, with very few, fine punctae; ovipositor somewhat exserted, one-sixth the length of abdomen.

Holotype female partly dissected on slide No. 69/B and rest on pin, labelled: "Parasitising *Cirphis* larvae, Pusa, T.B.F., 17-7-1914."

Neoclystopsenella, gen. nov.

Head viewed in front broadly oval; eyes bare, bulging; vertex broad, emarginate; ocelli large, arranged in a broad triangle; anterior ocellus situated on the frons at a position, just above the face; antennae 13-jointed; inserted just above the clypeus; scape long, clyindrical, as long as the length of head viewed in front and five times or more than the pedicel; mandible large, pincer-shaped with only one tooth apically and numerous very small serrations ventrally; maxillary palpi long, 6-jointed. Pronotum very short; mesonotum large ; parapsidal furrows finely indicated; scutellum convex. Abdomen oval, dorsoventrally somewhat flattened; first tergite much longer than the rest and cover one-third the whole length of thorax; male genitalia pincer-like and prominent. Fore wings hyaline; pterostigma and subcosta light brown, rest of veins clear and indistinct; two closed basal cells; radial cell closed, apex of radial vein indistinct; radial arises in the middle of somewhat elliptical pterostigma; basal joining the subcosta far ahead of the joining of the subcosta to pterostigma; cubital cell appears closed; hind wing with seven frenular hooks. Legs normal, fore and hind femur not unusually swollen; claw simple. Genotype *Neoclystopsenella luffae*, sp. nov.

This genus runs close to *Clystopsenella* in couplet No. 102 in Kieffer's key to genera of Bethylidae[1], but is easily distinguished in having simple claw and the basal ending before the distal end of subcosta.

Neoclystopsenella luffae, sp. nov.

Male.—Length 2.4 mm. Colour reddish-brown. Head reddish-brown to black; viewed from above nearly rectangular; length two-thirds the width;

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[1] KIEFFER, 1914. *Das Tierreich,* 41 : 1-595.

interorbital somewhat more than half the width of the head; eyes somewhat large, bulging, dark brown, bare; width of eye nearly equal to post-orbital length; vertex broad, irregularly transversely rugoso-carinate; ocelli large, reddish-brown interocellar space equal to ocellocular and both are slightly more than one and a half times the front ocellar; viewed in front (Fig. 255) length somewhat more than three-fourths the width of the head; interorbital space slightly more than half the width of the head; length of eye eight or nine times that of the very short gena; frons and face irregularly rugoso-carinately sculptured as on the vertex; clypeus more faintly and finely sculptured, somewhat prominent, broad and truncate; mandible brown, large, pincer-shaped, with only one tooth apically and numerous very small serrations ventrally; maxillary palpi long, 6-jointed. Antennae long, brown, inserted below the middle of face, slightly above an imaginary line joining the lower orbital borders; somewhat shorter than the length of the body; scape long, cylindrical, as long as the length of head viewed in front; six times the pedicel, first flagellar joint nearly as long as the pedicel; second flagellar one and one-fourth the first; third and succeeding joints subequal and slightly shorter than the second; the terminal joint one and a half times the penultimate and slightly less than one-third the scape (Fig. 253).

Thorax reddish-brown; somewhat less than twice the width of thorax at the region of the tegulae; mesothorax very slightly over half the length of the whole thorax; reddish-brown; with a dark longitudinal band medially and two such but fainter bands laterally; faintly, irregularly, rugosely sculptured; scutellum very slightly more than one-third the mesothorax and sculptured as on the latter; metathorax one-fourth the scutellum; propodeum slightly more than the scutellum and metathorax combined; faintly irregularly coriaceously sculptured. Legs normal, light-brown; fore coxa very slightly over twice the trochanter; femur twice the coxa and three and three-fourths the trochanter; tbiia very slightly over five-sixths the femur; tibial spur nearly two-fifths the tibia and two-thirds the metatarsus; metatarsus three-fifths the tibia and equal to rest of tarsi combined (Fig. 252). Hind coxa slightly less than two and a half times the trochanter; femur five and three-fourths the trochanter; tibia five-sixths the femur; tibial spur one-third the tibia and slightly less than half the metatarsus; metatarsus more than two-thirds the tibia (Fig. 254). Fore wing length somewhat more than two and three-fourths the breadth; hyaline; pterostigma and subcosta light brown, rest of veins clear or indistinct; two closed basal cells; radial cell closed; radial vein arising in the middle of somewhat elliptical pterostigma, long, reaching the margin, apex of vein indistinct; radial less than one-third the whole length of wing; basal joins subcosta far ahead of the latter joining pterostigma, slightly more than one-third the radius and nearly twice the transversal; pterostigma length nearly thrice the breadth; very slightly less than half the length of radius; rest of details and hind wing as in fig. 249 and 250. Abdomen oval, with a very short petiole; six tergites clearly visible; first tergite one-third the whole length of abdomen; rest of tergites short and gradually become shorter; male genitalia pincer-like and about one-fifth the length of abdomen (Fig. 251).

Holotype male, completely dissected and mounted on slide No. 92/B; paratypes 2 males, 77/B, and 79/B, all labelled: "Delhi, Kapoor Coll:, 2-7-1938, on Luffa, Imperial Entomologist" and 1 male, 55/B labelled: "Delhi, Kapoor Coll:, 5-7-1938, on cowpea, Imperial Entomologist."

PARASITE-HOST INDEX

Bethylus distigma Motsch.	*Agrotera basinotata Hamps.*
	Cacoecia sp.
	Chalcidoptera straminalis Guen.
	Homona coffearia Nietn.
	Hyblaea puera Cram.
	Lygropia quaternalis Zell.
	Sylepta (?) *crotonalis*
Chlorodryinus pallidus Perkins	nymphs of *Pyrilla* sp.
	nymphs of fulgorid, probably *Siphanta* sp.
Digonatopus lucidus Rohwer	nymphs of *Nephotettix bipunctatus* (Fabr.)
Goniozus chatterjii, sp. nov.	Pyralidae larvae defoliating mulberry
Goniozus fulvicornis (Rohwer)	*Argyroploce illepida* Butler
	Cryptophlebia carpophaga Wlsm.
Goniozus hypsipylae, sp. nov.	*Hypsipyla robusta*
Goniozus indicus Ashmead	*Chilo* sp.
	Diatraea venosata (Walk.)
	Emmalocera depressella Swinh.
	Scirpophaga auriflua Zell.
	Scirpophaga chrysorrhoea Zell.
	Scirpophaga intacta Snell
	Scirpophaga monostigma Zell.
	Scirpophaga nivella
	Scirpophaga sp.
Goniozus lygropiae, sp. nov.	*Lygropia* sp.
Goniozus madrassipattanami, sp. nov.	*Hapalia machaeralis*
Goniozus marasmi, sp. nov.	*Marasmia trapezalis*
Goniozus nephoterycis Kurian	*Nephopteryx* larvae binding leaves of *Cassia fistula*
Goniozus thalasodi, sp. nov.	*Thalasodes vevaria* on litchi leaves
Goniozus williamsi Bridwell	group of Lepidopterous larvae probably Pyralid
Haplogonatopus orientalis Rohwer	nymphs of *Sogata* sp. on paddy leaves
Laelius voracis Muesebeck	larvae of *Anthrenus vorax* (Waterh.)
Lestodryinus pyrillae Kieffer	*Pyrilla aberrans*
	Pyrilla perpusilla
	Pyrilla pusana
	Pyrilla sp.
Mesodryinus indicus Kieffer	*Phromnia marginella* nymphs
Odontepyris argyriae Kurian	*Argyria sticticraspis*
Odontepyris cirphi, sp. nov.	Cirphis larva
Perisierola quadrifoveata Muesebeck	cocoon from a betel leaf
Perisierola angulata Muesebeck	*Grapholitha molesta* Busck.
Perisierola mellipes Muesebeck	unknown host on Margosa
Perisierola nephantidis Muesebeck	*Nephantis serinopa*

[This parasite is recorded by Ramakrishna Iyer as the host of one species of *Pleurotropis* (Chalcidoidea) which he bred].

Perisierola pulveriae Kurian	*Holcocera pulverea* predator on *Laccifer lacca*
Perisierola salvadorae Kurian	Psyllid galls on *Salvadora persica*
Pseudogonatopus pyrillae Mani	Nymphs of *Pyrilla* sp.
Pseudogonatopus sogatea Rohwer	*Sogata distincta* Dist.
	Sogata pallescens Dist.
	Sogata pusana Dist.
Scleroderma delhiensis, sp. nov.	Bostrichidae
Scleroderma hardwickiae sp. nov.	Lyctidae
Scleroderma mori, sp. nov.	Anobiidae probably *Ptilinus binodulus* Motschulsky

(*Scleroderma* species often develop on larvae of Cerambycidae, living in wood-work of houses).

Host-Parasite Index

Agrotera basinotata Hamps.	*Bethylus distigma* Motsch.
Anthrenus vorax Waterhouse	*Laelius voracis* Muesebeck
Argyria sticticraspis	*Odontepyris argyriae* Kurian
Argyroploce illepida Butler	*Goniozus fulvicornis* (Rohwer)
Asphondylia morindae Mani	*Goniozus morindae* Kurian
Bostrichidae	*Scleroderma delhiensis*, sp. nov.
Cacoecia sp.	*Bethylus distigma* Motsch
Chalcidoptera straminalis	*Bethylus distigma* Motsch.
Chilo sp.	*Goniozus indicus* Ashmead
Cirphis larva	*Odontepyris cirphi*, sp. nov.
Diatraea venosata (Walk.)	*Goniozus indicus* Ashmead
Emmalocera depressella Swinh.	*Goniozus indicus* Ashmead
Hapalia machaeralis	*Goniozus madrassippattanami*, sp. nov.
Holcocera pulverea predator on *Laccifer lacca*	*Perisierola pulveriae* Kurian
Homona coffearia Nietn.	*Bethylus distigma* Motschulsky
Hyblaea puera Cram.	*Bethylus distigma* Motschulsky
	Goniozus hybleae, sp. nov.
Hypsipyla robusta	*Goniozus hypsipylae*, sp. nov.
Jassids	*Pseudogonatopus sogatea* Rohwer
Lygropia quaternalis Zell.	*Bethylus distigma* Motschulsky
Lygropia sp.	*Goniozus lygropiae*, sp. nov.
Lyctidae	*Scleroderma hardwickiae*, sp. nov.
Nephantis serinopa	*Perisierola nephantidis* Muesebeck
	(This is attacked by a species of *Pleurotropis* (Entedoninae)
Nephopteryx larvae binding leaves of *Cassia* fistula	*Goniozus nephoterycis* Kurian
Nephotettix bipunctatus (Fabr.)	*Digonatopus lucidus* Rohwer
Phromnia marginella	*Mesodryinus indicus* Kieffer
Platyedra gossypiella (Saund.)	*Bethylus* sp.
Psyllid galls on *Salvadora persica*	*Perisierola salvadorae* Kurian
Ptilinus binodulus Motsch.	*Scleroderma mori*, sp. nov.
Pyralidae larva defoliating mulberry	*Goniozus chatterjii*, sp. nov.
Pyrilla sp.	*Chlorodryinus pallidus* Perkins
Pyrilla sp.	*Lestodryinus pyrillae* Kieffer
Scirpophaga auriflua Zell.	*Goniozus indicus* Ashmead
Scirpophaga chrysorrhoea Zell.	*Goniozus indicus* Ashmead
Scirpophaga intacta Snell	*Goniozus indicus* Ashmead

Scirpophaga monostigma Zell.	*Goniozus indicus* Ashmead
Scirpophaga nivella (Fabr.)	*Goniozus indicus* Ashmead
Scirpophaga sp.	*Goniozus indicus* Ashmead
Sogata distincta Dist.	*Pseudogonatopus sogatea* Rohwer
Sogat pallescens Dist.	*Pseudogonatopus sogatea* Rohwer
Sogata pusana Dist.	*Pseudogonatopus sogatea* Rohwer
Sogata sp.	*Haplogonatopus orientalis* Rohwer
Sylepta (?) *crotonalis*	*Bethylus distigma* Motsch.

Explanation of Figures

Fig. 1-6. *Lestodryinus guptai*, sp. nov. 1. fore wing, 2. hind wing, 3. antenna, 4. tarsi of fore leg enlarged, 5. fore leg excluding coxa, trochanter and femur, 6. hind leg excluding coxa and trochanter.

Fig. 7-12. *Lestodryinus pyrillae* Kieffer. 7. fore wing, 8. hind wing, 9. antenna, 10. hind leg, 11. fore leg, 12. chela of fore leg enlarged.

Fig. 13-18. *Lestodryinus pyrillae* Kieffer. 13. fore wing, 14. hind wing, 16. hind leg, 16. antenna, 17. last tarsus and claw of hind leg enlarged, 18. fore leg excluding coxa.

Fig. 19-22. *Paradryinus kevirae* Lal. 19. antenna, 20. femur and tibia of fore leg, 21. fore wing, 22. hind wing.

Fig. 23-27. *Chlorodryinus pallidus* Perkins. 23. fore wing, 24. hind wing, 25. antenna, 26. fore leg, 27. hind leg.

Fig. 28-32. *Chlorodryinus pallidus* Perkins. 28. fore wing, 29. hind wing, 30. antenna, 31. fore leg, 32. hind leg.

Fig. 33-38. *Neodryinus karnalensis*, sp. nov. 33. fore wing, 34. hind wing, 35. antenna, 36. hind leg excluding coxa, 37. last two tarsi and claw of hind leg enlarged, 38. fore leg excluding coxa.

Fig. 39-44. *Neodryinus pusaensis*, sp. nov. 39. fore wing, 40. hind wing, 41. antenna, 42. last two tarsi and claw of hind leg enlarged, 43. fore leg, 44. hind leg.

Fig. 45-47. *Cephalonomia tritici*, sp. nov. 45. fore wing, 46. basal joints of antenna, 47. hind leg.

Fig. 48-51. *Scleroderma delhiensis*, sp. nov. 48. antenna, 49. fore leg, 50. last tarsus and claw of hind leg enlarged, 51. hind leg.

Fig. 52. *Scleroderma hardwickiae*, sp. nov. 52. basal joints of antenna.

Fig. 53-58. *Scleroderma mori*, sp. nov. 53. fore wing, 54. hind wing, 55. fore leg, 56. basal joints of antenna enlarged, 57. antenna, 58. hind leg.

Fig. 59-64. *Laelius agraensis*, sp. nov. 59. fore wing, 60. hind wing, 61. antenna, 62. last tarsus and claw of hind leg enlarged, 62. hind leg, 64. fore leg.

Fig. 65-69. *Mesitius bahaduri*, sp. nov. 65. fore wing, 66. hind wing, 67. antenna, 68. hind leg, 69. fore leg.

Fig. 70-75. *Mesitius duni*, sp. nov. 70. antenna, 71. fore leg, 72. fore wing, 73. hind wing, 74. hind leg, 75. last tarsus and claw of hind leg enlarged.

Fig. 76-80. *Lustrina assamensis*, gen. et. sp. nov. 76. fore wing, 77. hind wing, 78. hind leg, 79. antenna, 80. fore leg.

Fig. 81-85. *Epyris agrensis*, sp. nov. 81. antenna, 82. fore wing, 83. hind wing, 84. hind leg, 85. fore leg excluding coxa.

Fig. 86-90. *Epyris delhiensis*, sp. nov. 86. fore wing, 87. hind wing, 88. hind leg excluding coxa, 89. last tarsus and claw of hind leg enlarged, 90. fore leg.

Fig. 91-95. *Epyris duttai*, sp. nov. 91. fore wing, 92. hind wing, 93. antenna, 94. hind leg, 95. fore leg.

Fig. 96-101. *Epyris manii*, sp. nov. 96. fore wing, 97. hind wing, 98. hind leg excluding coxa and trochanter, 99. antenna, 100. fore leg excluding last two tarsi, 101. last two tarsi and claw of hind leg enlarged.

Fig. 102-106. *Epyria manii*, sp. nov. 102. fore wing, 103. hind wing, 104. antenna, 105. hind leg excluding coxa, 106. fore leg excluding coxa.

Fig. 107-111. *Epyris patnae*, sp. nov. 107. antenna, 108. fore wing, 109. hind wing, 110. fore leg, 111. hind leg excluding last two tarsi.

Fig. 112-117. *Rhabdepyris agraensis*, sp. nov. 112. fore wing, 113. hind wing, 114. antenna, 115. fore leg, 116. last two tarsi and claw of hind leg enlarged, 117. hind leg.

Fig. 118-123. *Apenesia raonis*, sp. nov. 118. fore wing, 119. hind wing, 120. antenna, 121. fore leg excluding coxa and trochanter, 122. hind leg excluding coxa, 123. last tarsus and claw of hind leg enlarged.

Fig. 124-129. *Chlorepyris biharina*, sp. nov. 124. fore wing, 125. hind wing, 126. antenna, 127. last tarsus and claw of hind leg enlarged, 128. hind leg, 129. fore leg excluding last tarsus.

Fig. 130-135. *Chlorepyris mackenziei*, sp. nov. 130. fore wing, 131. hind wing, 132. antenna, 133. fore leg excluding coxa, 134. last two tarsi and claw of hind leg enlarged, 135. fore leg excluding coxa, 134. last two tarsi and claw of hind leg enlarged, 735. hind leg excluding coxa trochanter and femur.

Fig. 136-140. *Chlorepyris pusana*, sp. nov. 136. fore wing, 137. antenna, 138. hind leg excluding last two tarsi, 139. fore leg, 140. last two tarsi and claw of hind leg enlarged.

Fig. 141-146. *Neodisepyris bombayensis*, gen. et sp. nov. 141. antenna, 142. fore wing, 143. hind wing, 144. fore leg excluding coxa, 145. last tarsus and claw of hind leg enlarged, 152. hind leg.

Fig. 147-152. *Neodisepyris duni*, gen. et sp. nov. 147. fore wing, 148. hind wing, 149. antenna, 150. fore leg excluding last tarsus, 151. last tarsus and claw of hind leg enlarged, 152. hind leg.

Fig. 153-158. *Neodisepyris indicae*, gen. et sp. nov. 153. fore wing, 154. hind wing, 155. antenna, 156. hind leg excluding coxa, torchanter and femur 157. last two tarsi and claw of hind leg enlarged, 158. fore leg.

Fig. 159-165. *Neodisepyris pusae*, gen. et sp. nov. 159. fore wing, 160. hind wing, 161. hind leg, 162. fore leg excluding coxa, 163. basal joints of antenna, 164. apical joints of antenna, 165. claw and last two tarsal joints of hind leg enlarged.

Fig. 166-170. *Neodisepyris shishami*, gen. et. sp. nov. 166. fore wing, 167. fore leg, 168. last tarsus and claw of hind leg enlarged, 169. hind leg, 170. antenna.

Fig. 171-175. *Goniozus ahmeadi*, sp. nov. 171. fore wing, 172. hind wing, 173. antenna, 174. fore leg excluding coxa and trochanter, 175. hind leg.

Fig. 176-181. *Goniozus chatterjii*, sp. nov. 176. fore wing, 177. hind wing, 178. antenna, 179. hind leg, 180. last tarsus and claw of hind leg enlarged, 181. fore leg.

Fig. 182-187. *Goniozus chowdhari*, sp. nov. 182. fore wing, 183. hind wing, 184. antenna, 185. fore leg, 186. last tarsus and claw of hind leg enlarged, 187. hind leg.

Fig. 188-193. *Goniozus hybleae*, sp. nov. 188. fore wing, 189. hind wing, 190. hind leg excluding coxa and trochanter, 191. fore leg excluding coxa, 192. last tarsus and claw of hind leg enlarged, 193. antenna.

Fig. 194-199. *Goniozus hypsipylae*, sp. nov. 194. fore wing, 195. hind wing, 196. antenna, 197. fore leg, 198. last tarsus and claw of hind leg enlarged, 199. hind leg.

Fig. 200-205. *Goniozus lygropiae*, sp. nov. 200. fore wing, 201. hind wing, 202. antenna, 203. hind leg, 204. last tarsus and claw of hind leg enlarged, 205. fore leg.

Fig. 206-210. *Goniozus madrassippattanami*, sp. nov. 206. fore wing, 207. hind wing, 208. antenna, 209. fore leg, 210. hind leg.

Fig. 211-215. *Goniozus marasmi*, sp. nov. 211. fore wing, 212. hind wing, 213. antenna, 214. fore leg, 215. hind leg.

Fig. 216-221. *Goniozus mori*, sp. nov. 216. fore wing, 217. hind wing, 218. last tarsus and claw of hind leg enlarged, 219. hind leg excluding coxa and trochanter, 220. fore leg, 221. antenna.

Fig. 222-226. *Goniozus nilamburensis*, sp. nov. 222. fore wing, 223. antenna, 224. hind leg excluding coxa, 225. fore leg excluding coxa, 226. last tarsus and claw of hind leg enlarged.

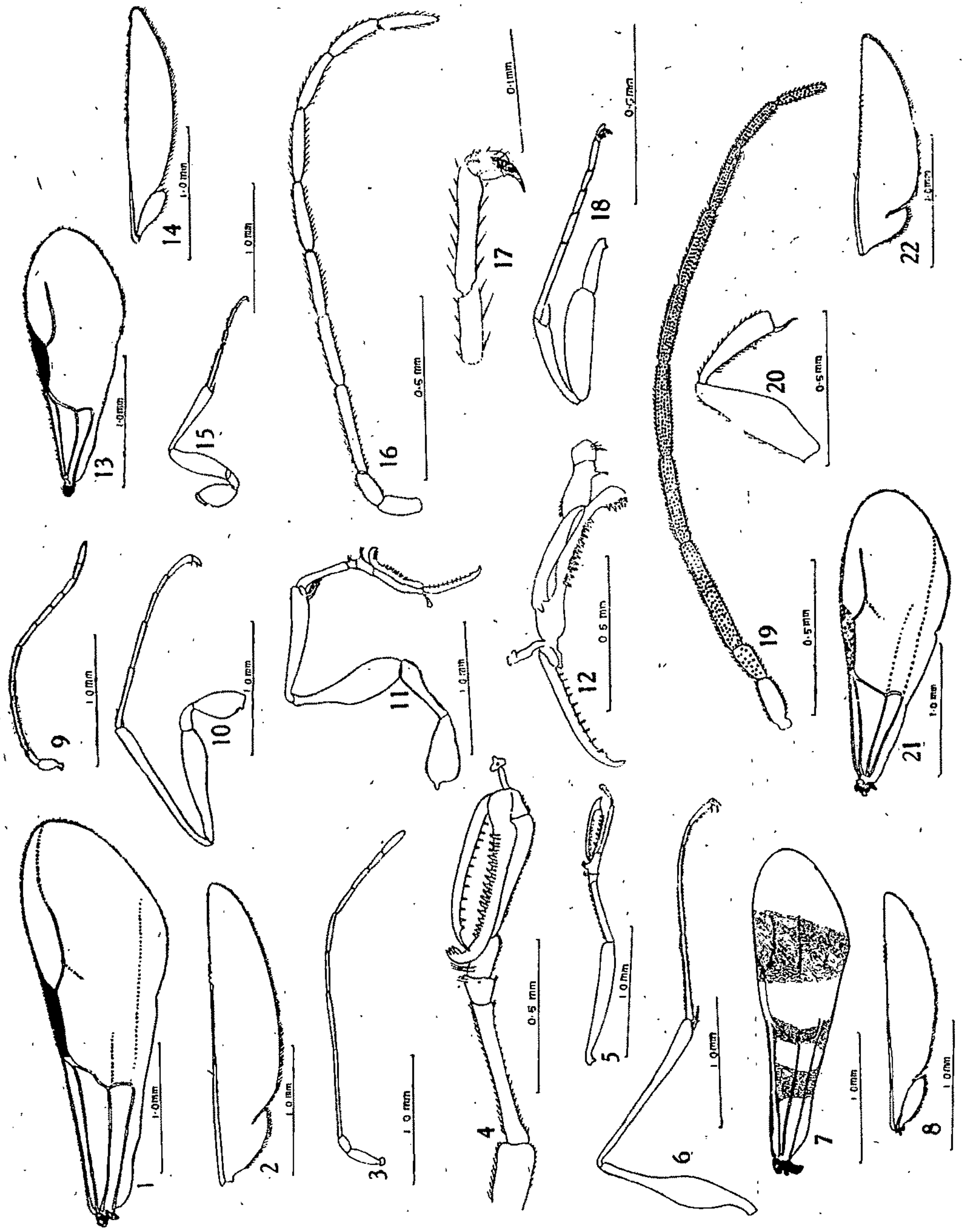
FIG. 227-231. *Goniozus sancti-johannis*, sp. nov. 227. fore wing, 228. hind wing, 229. hind leg, 230. antenna, 231. fore leg excluding coxa.

FIG. 232-236. *Goniozus thalasodi*, sp. nov. 232. antenna excluding scape, 233. fore wing, 234. fore leg, 235. last two tarsi and claw of hind leg enlarged, 236. hind leg.

FIG. 237-242. *Odontepyris batrae*, sp. nov. 237. fore wing, 238. hind wing, 239. antenna, 240. fore leg, 241. hind leg, 242. last tarsus and claw of hind leg enlarged.

FIG. 243-248. *Odontepyris cirphi*, sp. nov. 243. fore wing, 244. hind wing, 245. last two tarsi and claw of hind leg enlarged, 246. antenna, 247. fore leg, 248. hind leg.

FIG. 249-255. *Neoclystopsenella luffae*, gen. et sp. nov. 249. fore wing, 250. hind wing, 251. apex of abdomen, 252. fore leg excluding coxa, trochanter and femur 253. antenna, 254. hind leg, 255. head viewed in front.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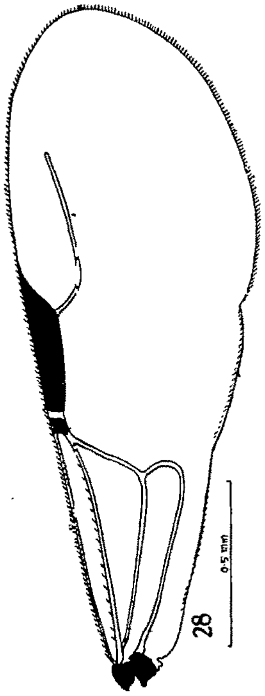

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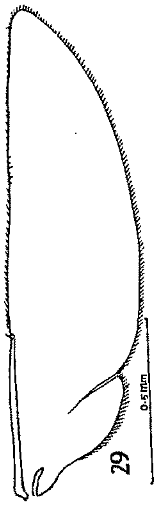

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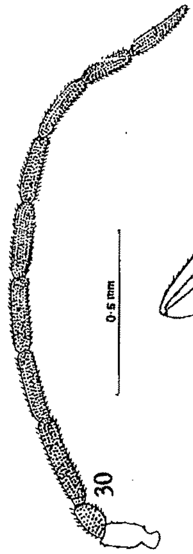

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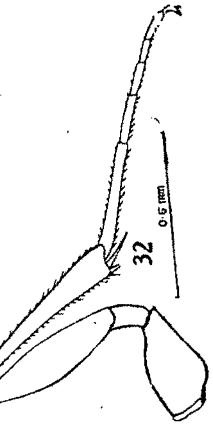

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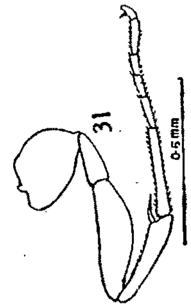

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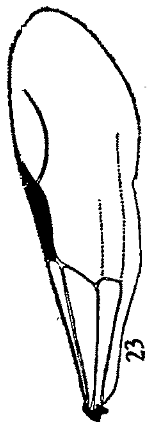

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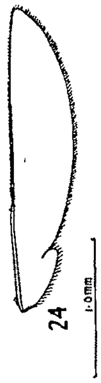

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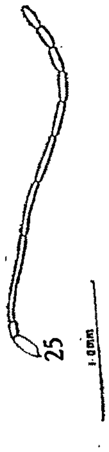

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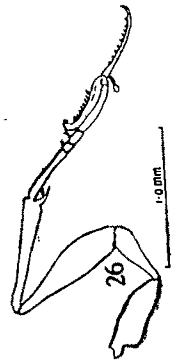

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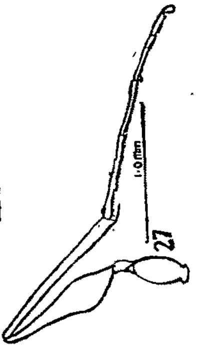

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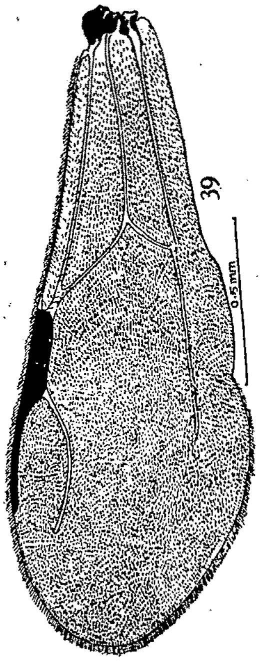
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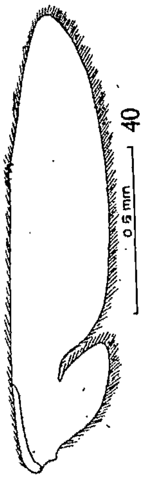
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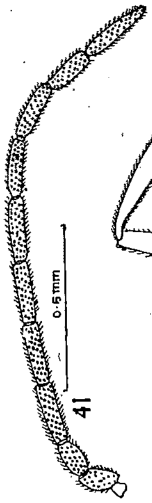
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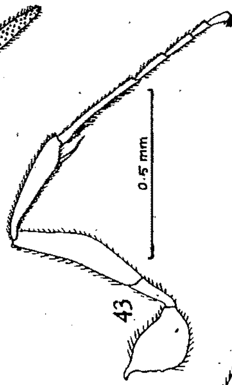
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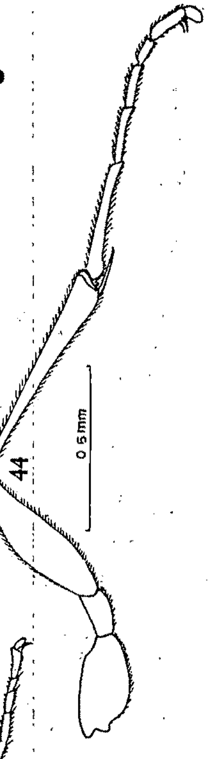
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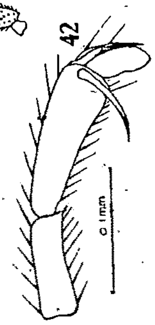
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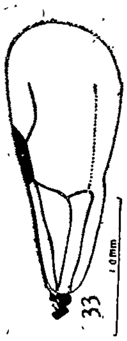
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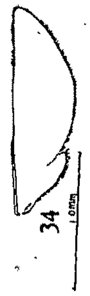
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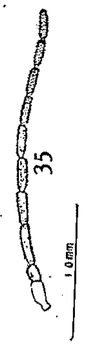
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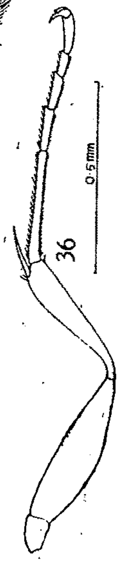
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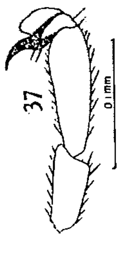
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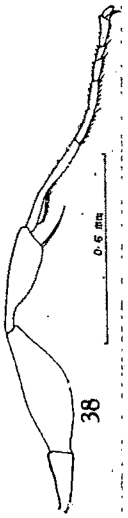
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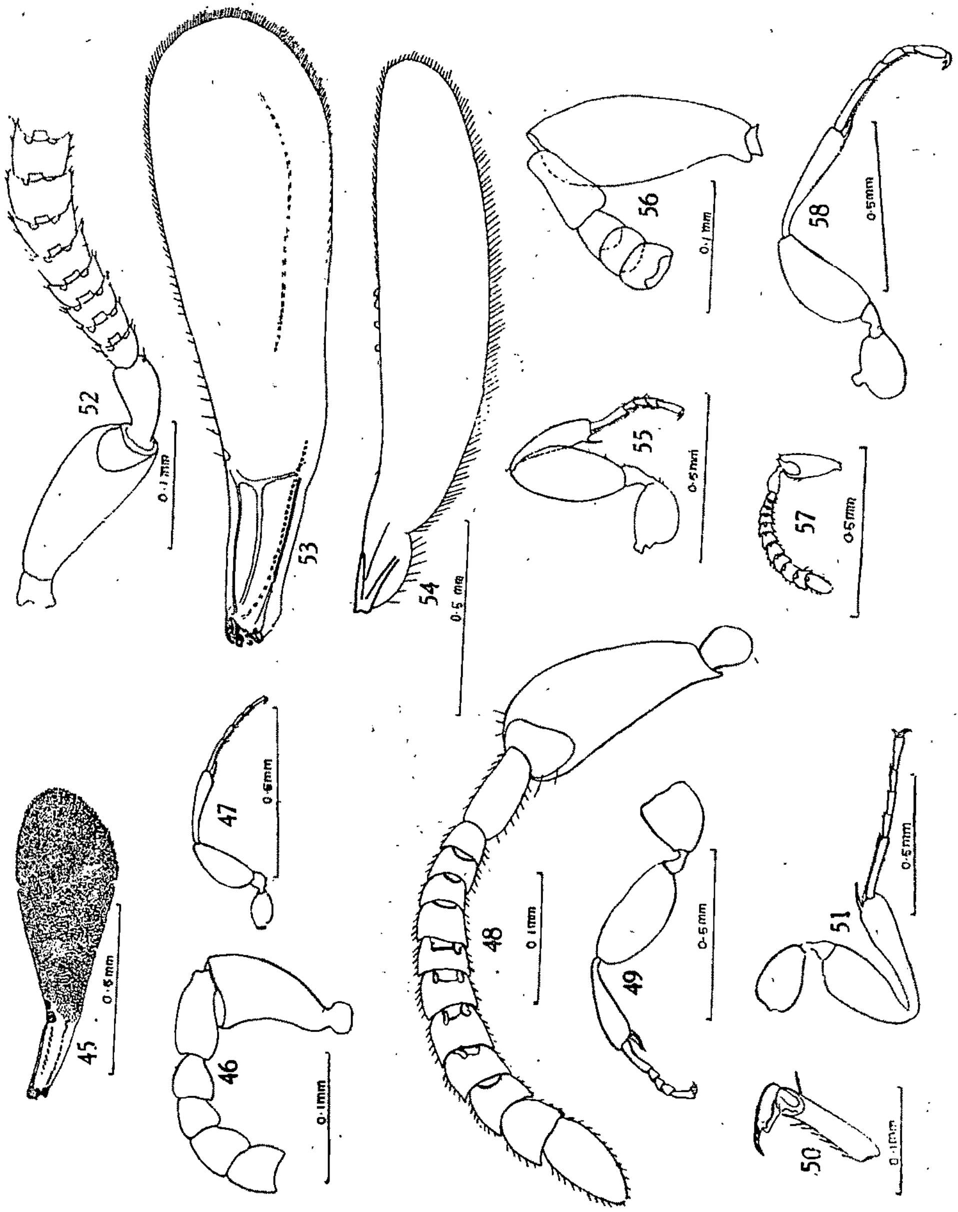
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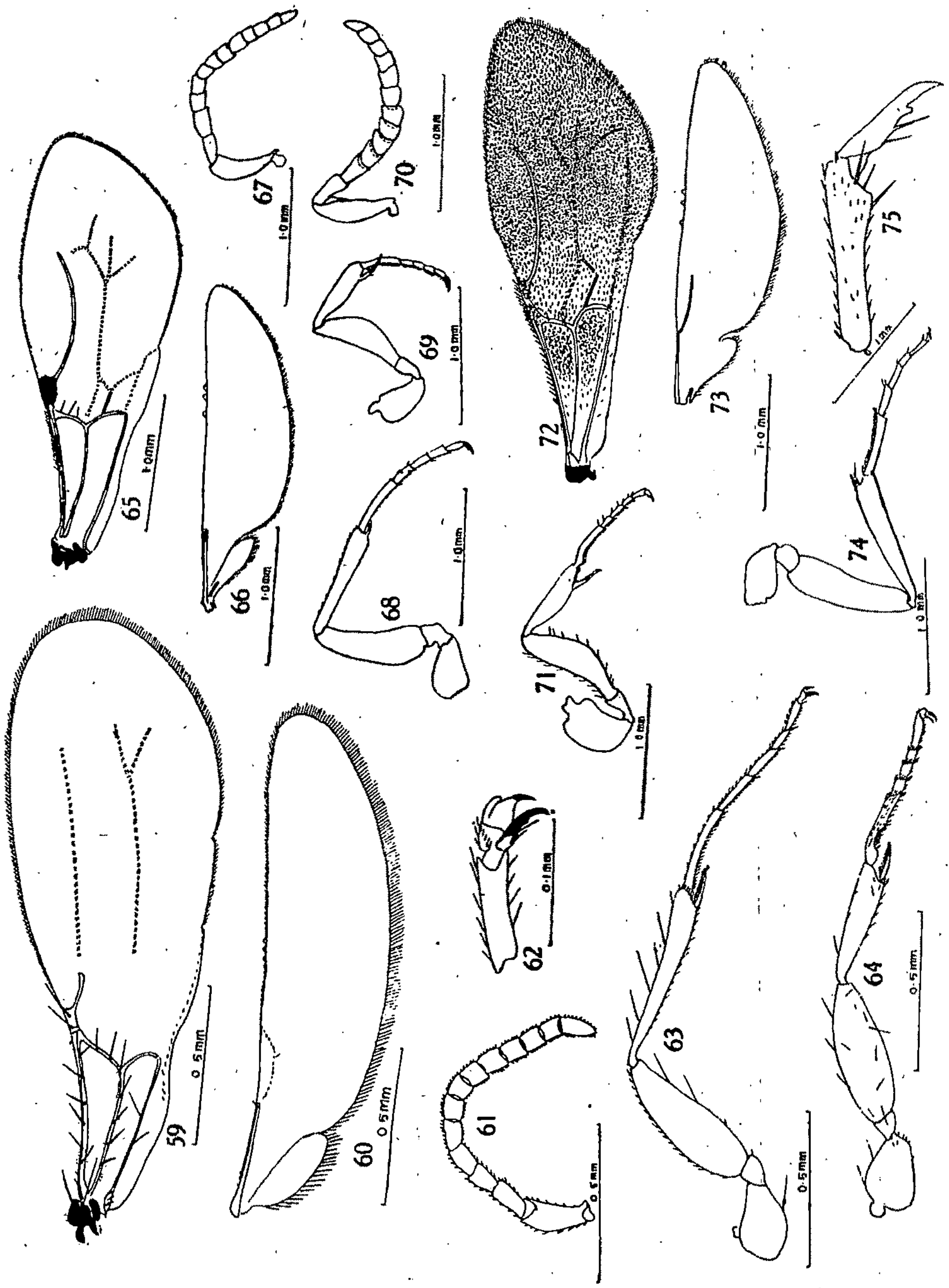
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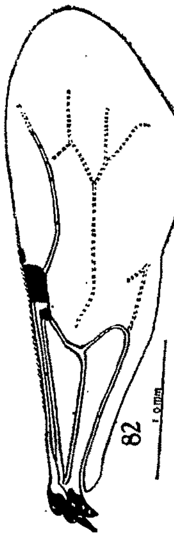
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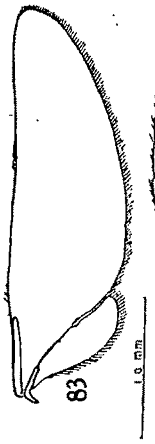
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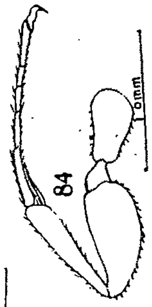
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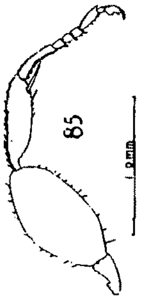
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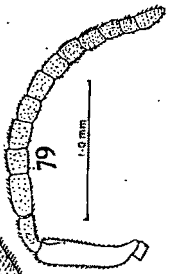
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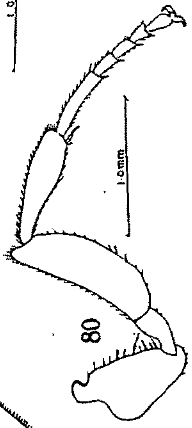
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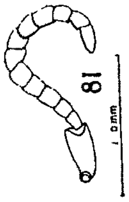
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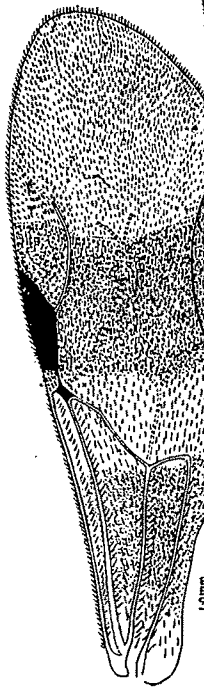
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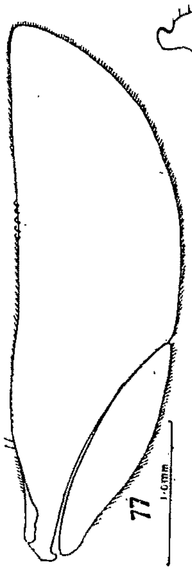
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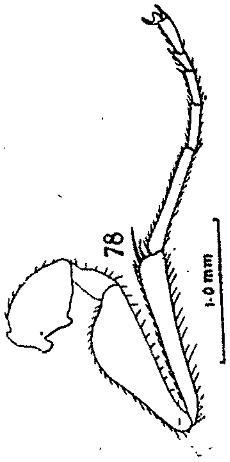
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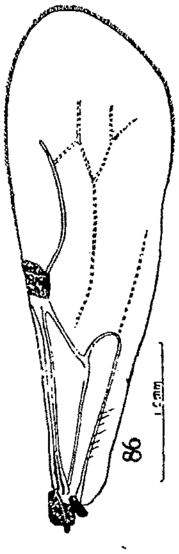
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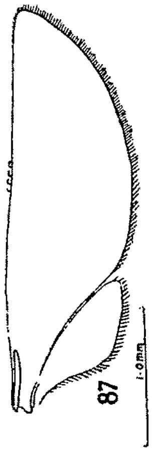
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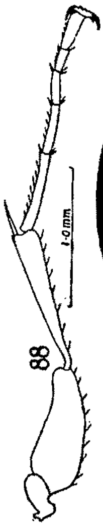
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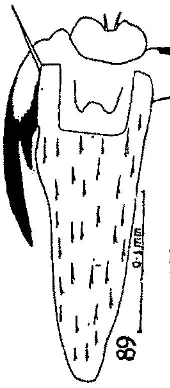
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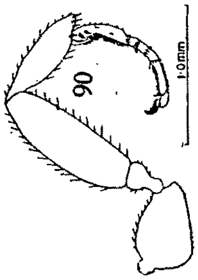
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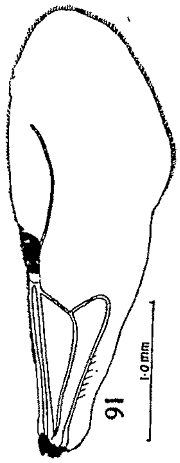
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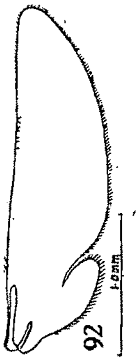
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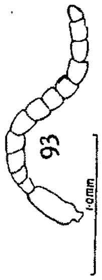
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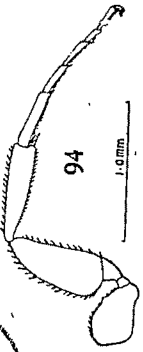
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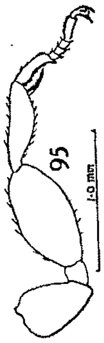
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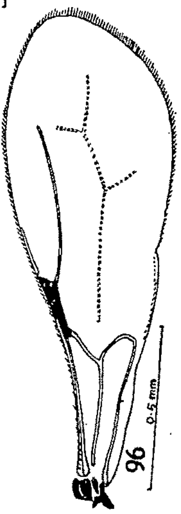
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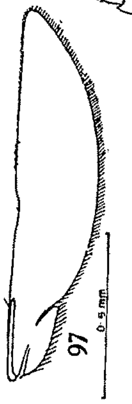
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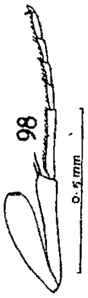
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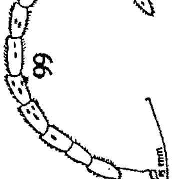
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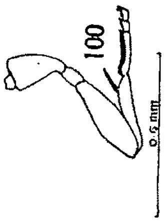
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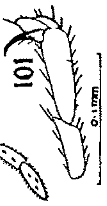
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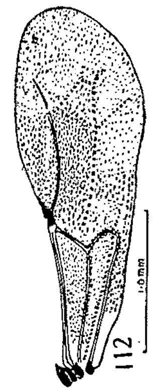

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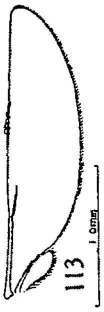

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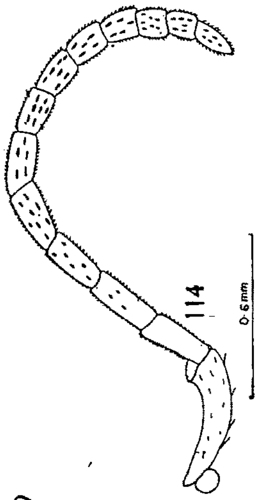

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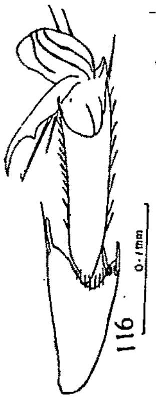

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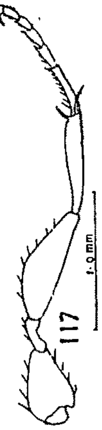

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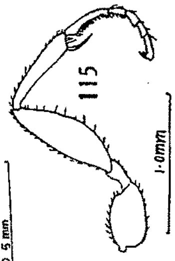

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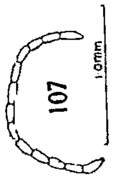

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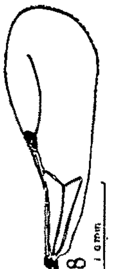

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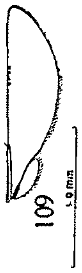

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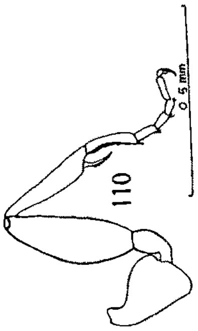

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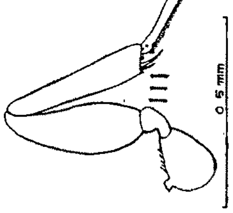

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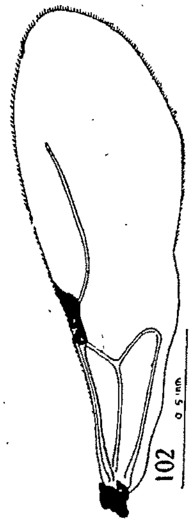

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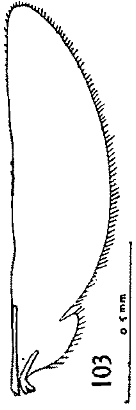

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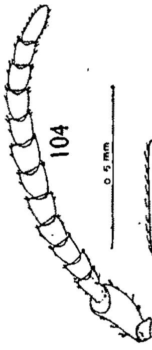

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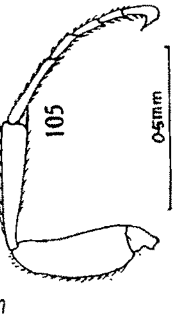

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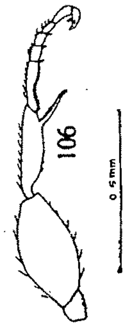

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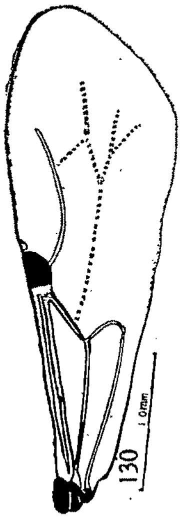

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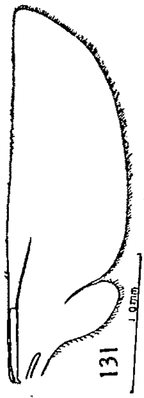

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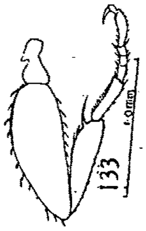

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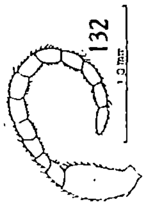

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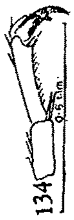

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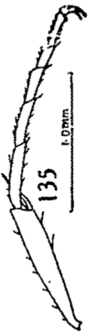

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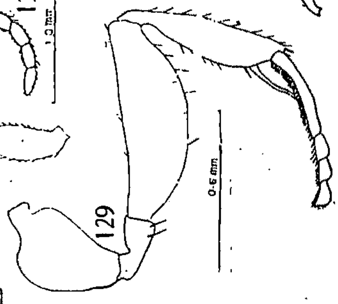

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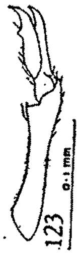

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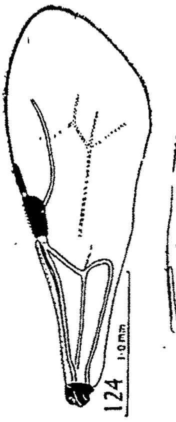

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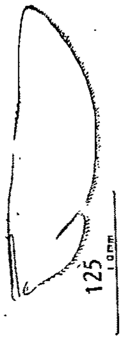

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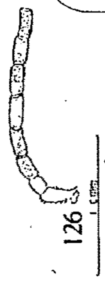

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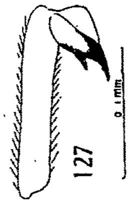

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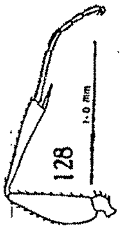

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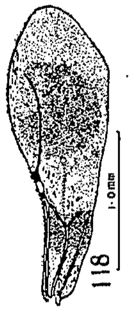

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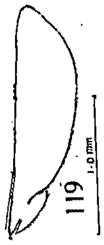

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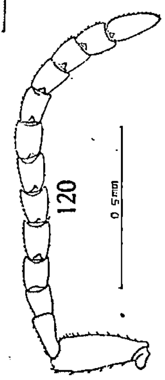

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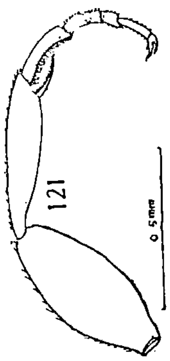

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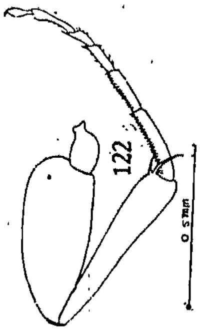

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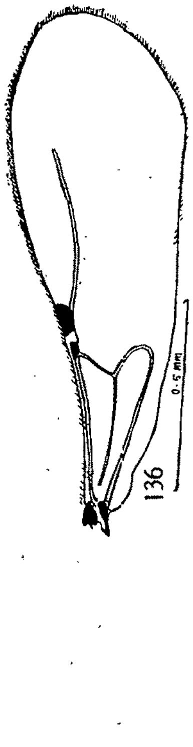
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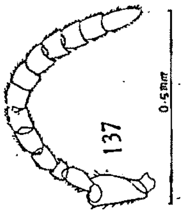
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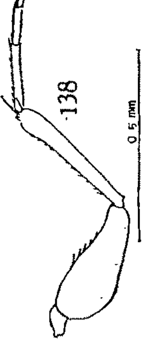
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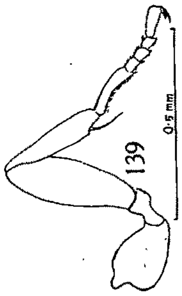
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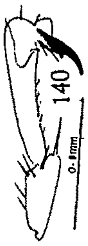
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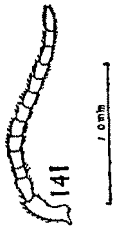
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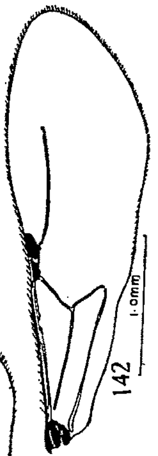
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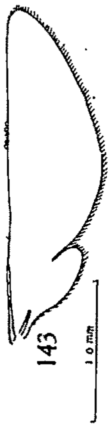
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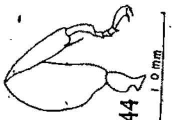
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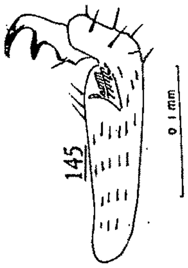
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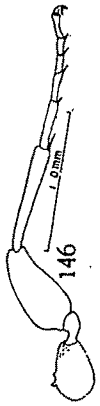
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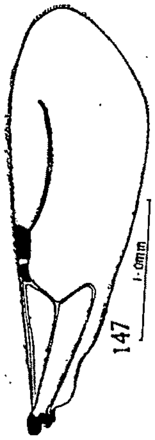
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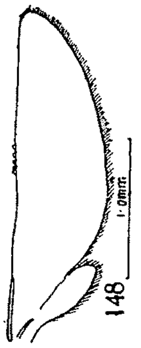
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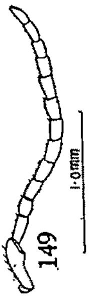
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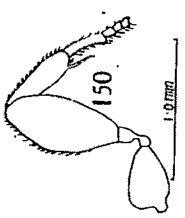
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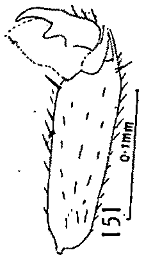
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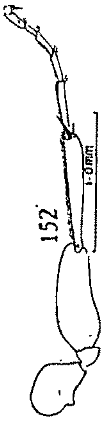
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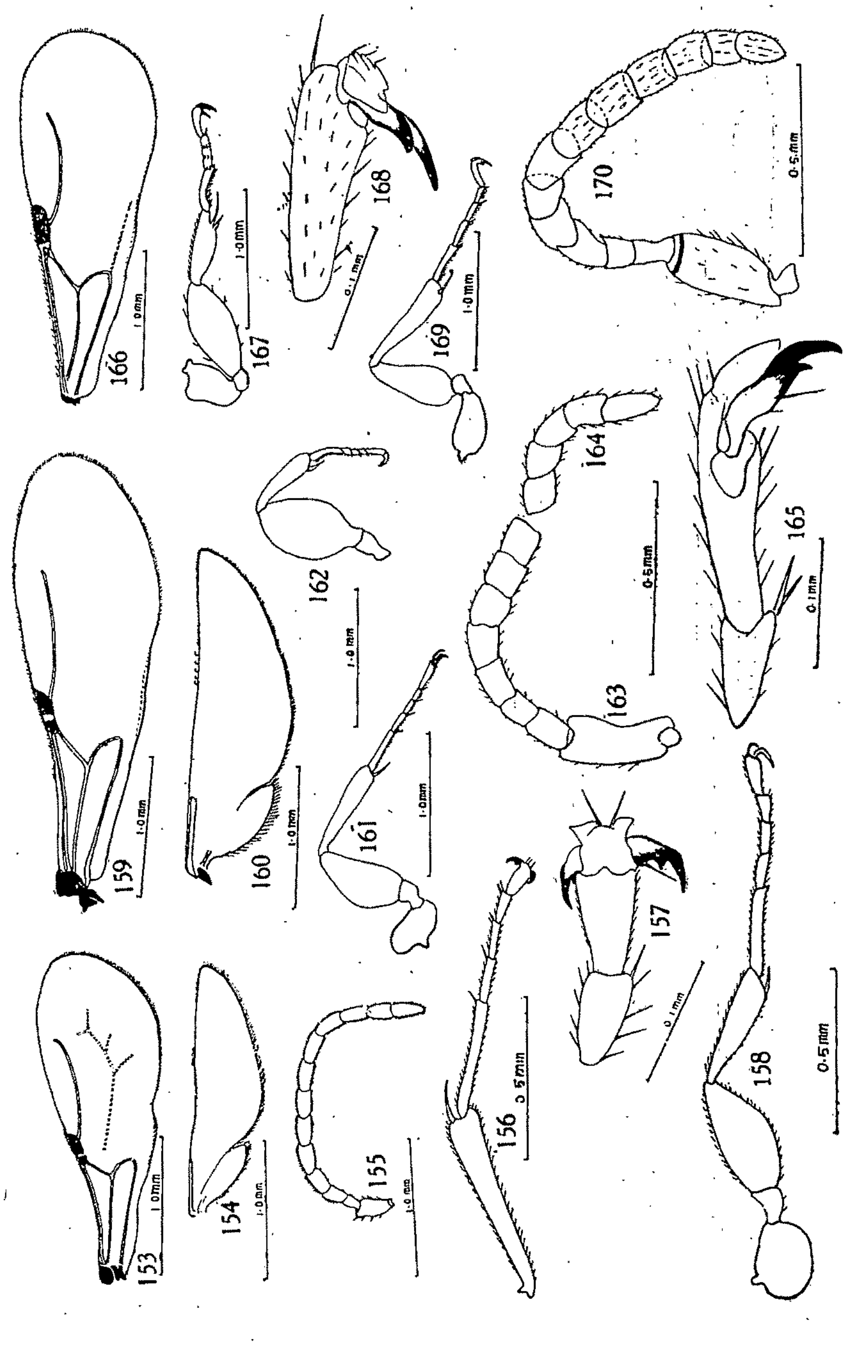
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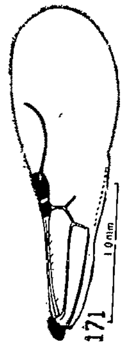
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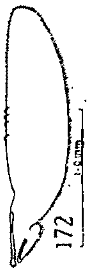
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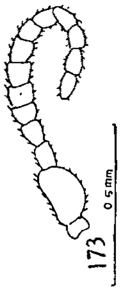
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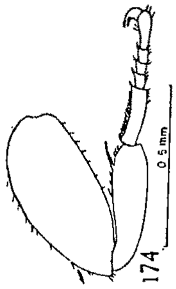
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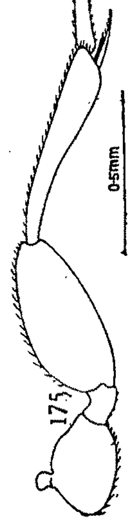
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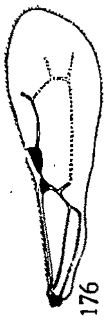
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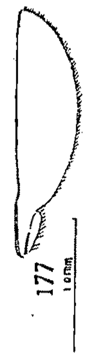
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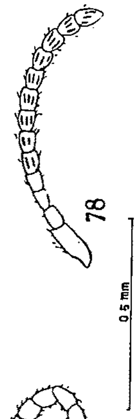
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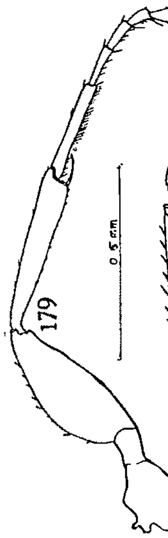
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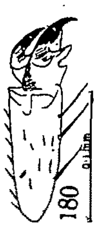
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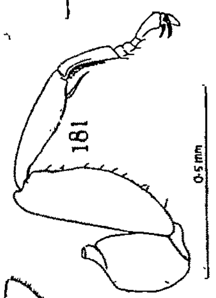
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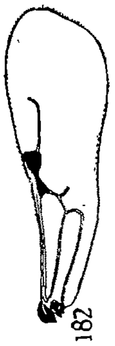
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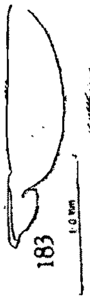
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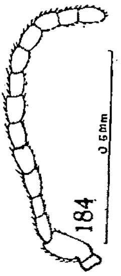
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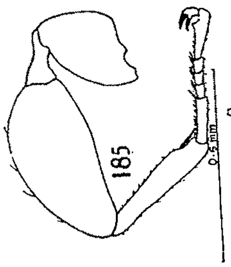
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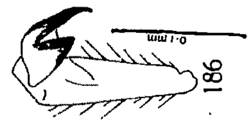
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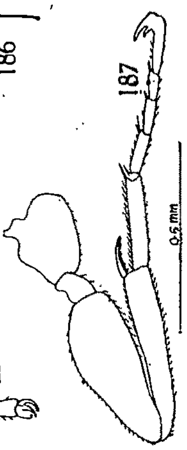
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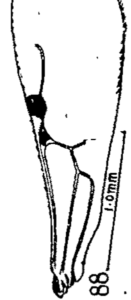
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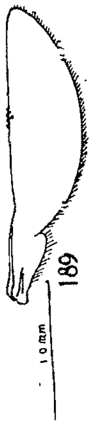
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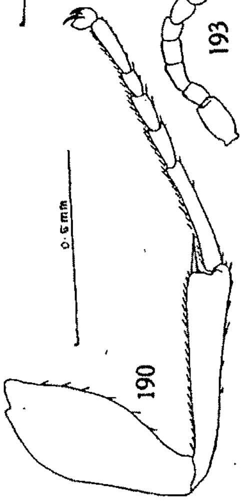
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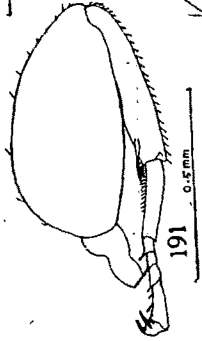
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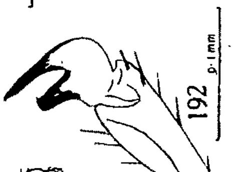
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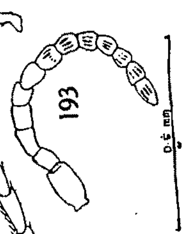
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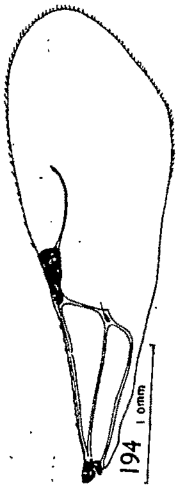
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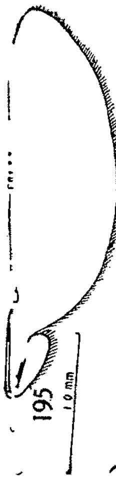
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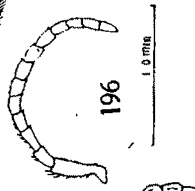
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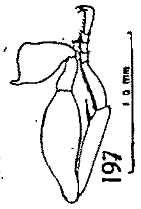
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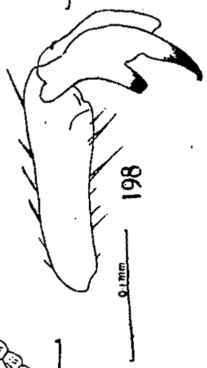
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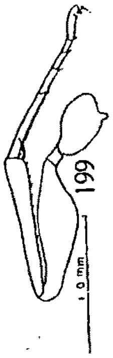
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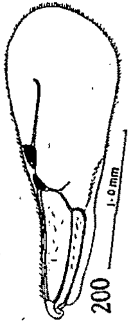
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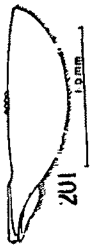
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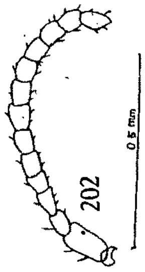
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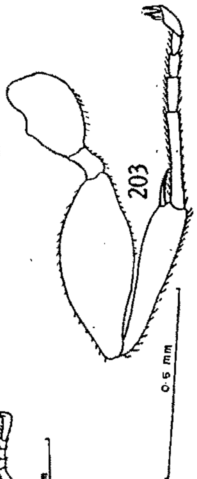
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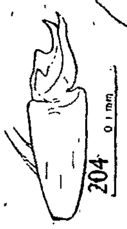
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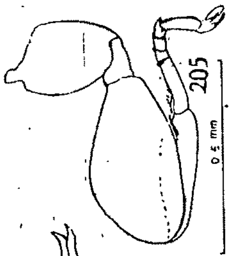
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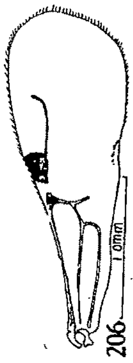
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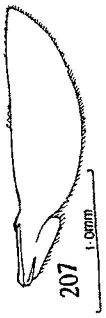
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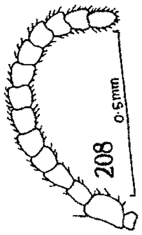
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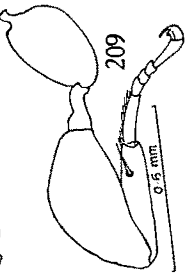
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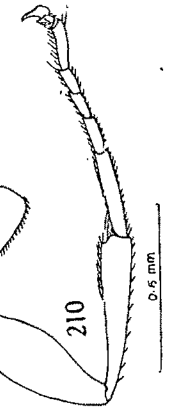
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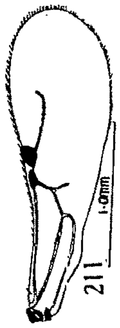
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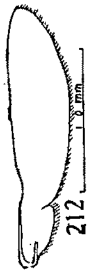
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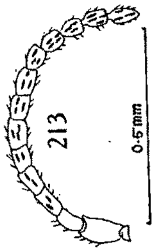
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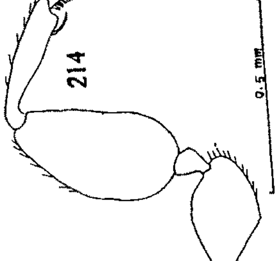
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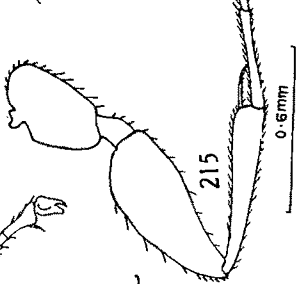
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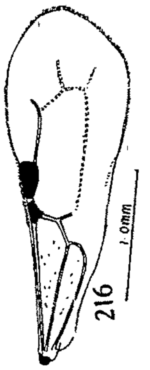
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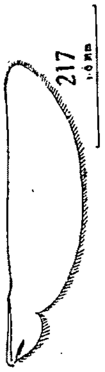
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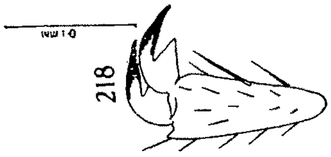
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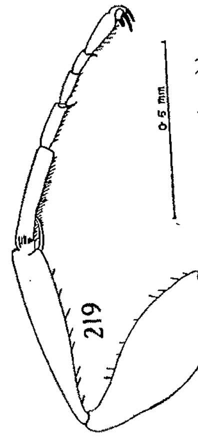
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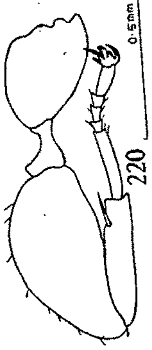
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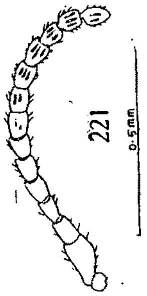
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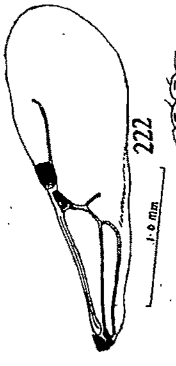
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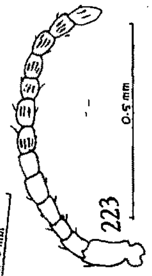
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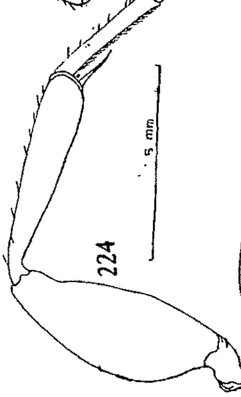
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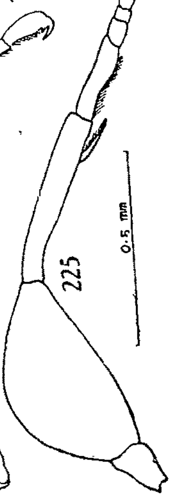
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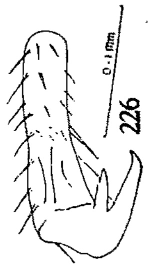
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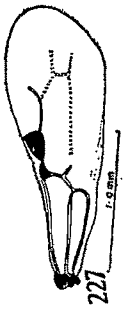
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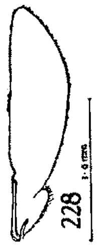
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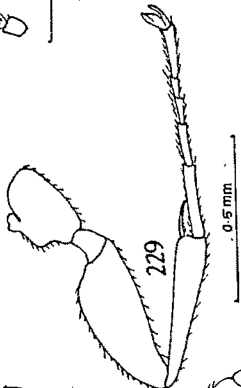
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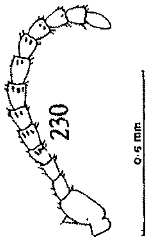
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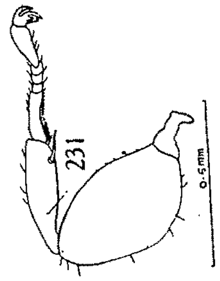
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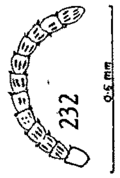
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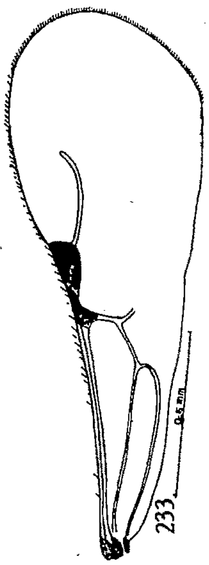
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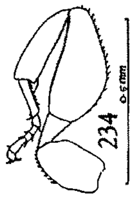
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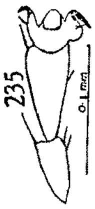
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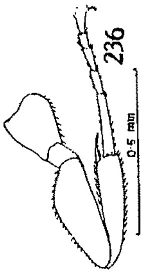
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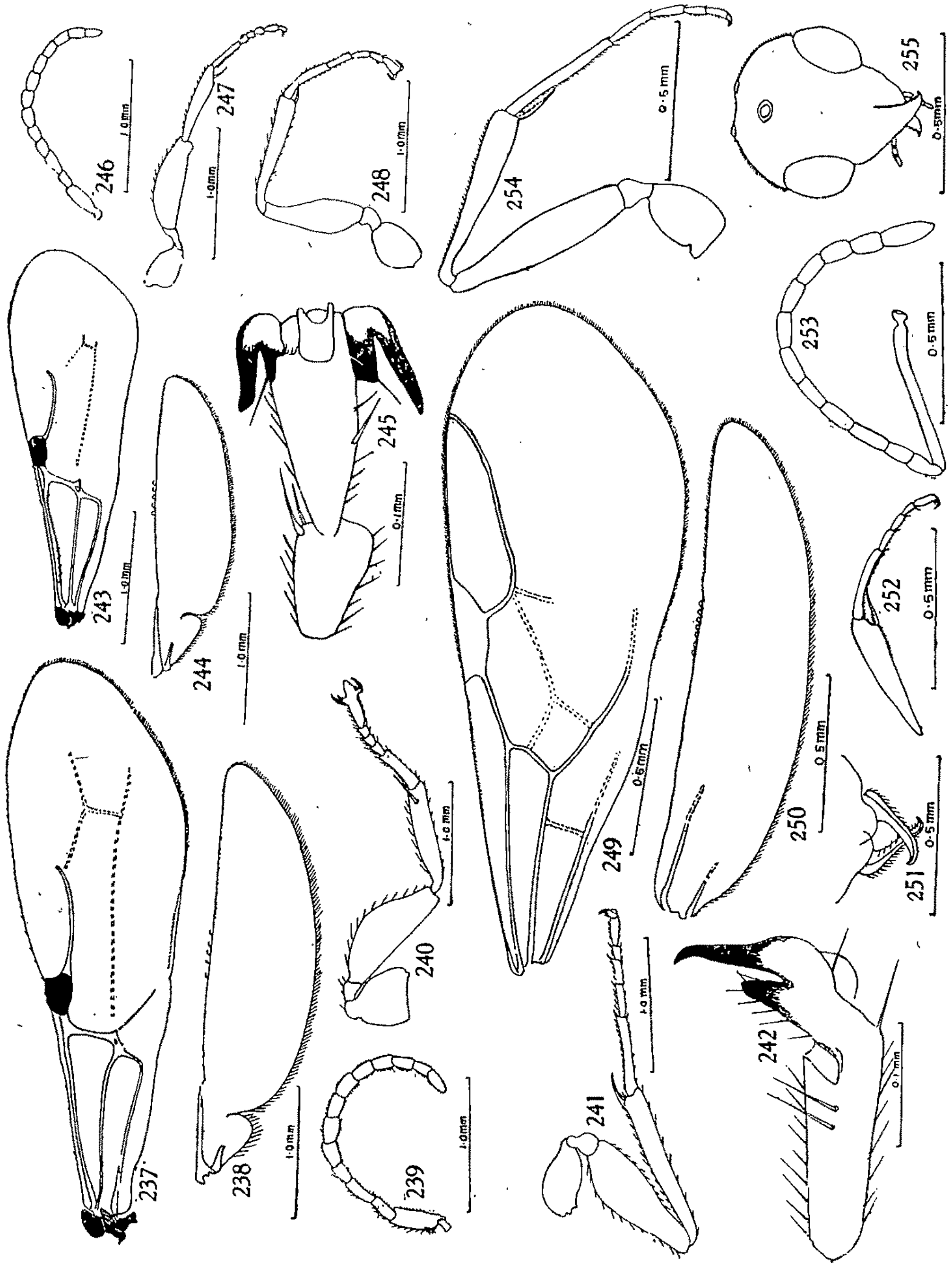
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ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

IV.—EXPEDITION TO THE UPPER CHENAB VALLEY—1954†

By M.S.MANI, M.A., D.Sc., F.R.E.S., F.L.S., *Professor of Zoology & Entomology, School of Entomology, St. John's College, Agra.*

This paper gives a brief account of the Entomological Expedition, which I led during summer 1954 to the Himalayas. Although we have been studying the insect life of the Himalayas for the past three years[1], this was the first expedition organized wholly for exploring insect life at high altitudes in the Himalayas. While the variety and abundance of insect life fall off rapidly beyond the limits of tree growth (between 12,000 ft and 10,000 ft), the zone of perpetual snows immediately above these limits is by no means barren of insect life. I had for example found in an earlier survey, insects up to 15,000 ft on the southern slopes of the outer Himalayas.[2]. The maximum altitudes up to which insects habitually occur, the peculiarities of distribution of insects on the outer and inner Himalayas, the habits and modifications in life-cycles, structural adaptations and the orders of insects which have become adapted for life at high altitudes are however still largely unknown. The 1954 Expedition had for its objective collection of material, which would form the basis for further investigations on some of these problems.

I was accompanied by my first son Mr M. Visvanath, one of my Research Associates Mr Santokh Singh and two other young colleagues Messrs R.V. Charley and John Healey, who had recently arrived from England. Both my son and Mr Santokh Singh had been with me on the Himalayas on previous occasions and had gained some experience of hiking, mountaineering and collecting. Neither Mr Charley nor Mr Healey had been on the Himalayas before, but had other unique qualities which made them valuable members of the Expedition.

THE EXPEDITION'S OBJECTIVE

The Expedition's objective was the upper reaches of the River Chenab from near its source and the surrounding mountains. The River Chenab is formed by the confluence of two icy-cold torrents, viz. River Chandra and River Bhaga, below Tandi (near 76°E.Long., 32°30′N.Lat., 10,000 ft above sea level), four miles to the west of Keylang, the capital of Lahoul Valley. River Chandra,

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*Contribution No. 54 from the School of Entomology.

†The Ministry of Education, Government of India, gave a small financial grant for part of the equipment of the Expedition.

[1] Mani, M. S. 1954. *Agra Univ. J. Res.* (Sci.), **3**(1): 13-42 ; Santokh Singh *et al.* 1954. *ibid.*, 3(2) : 385-400; Baijal, H. N. *et al.* 1954. *ibid.*, **3**(2) : 455-462.

[2] Large swarms of Collembola were found on snows at 14,000 ft. on Sach Pass, north of Baihalijot, Main Himalayas, by Parker, R. N. 1921. *J. Bombay nat. Hist. Soc.*, **27** : 639-641.

considered as the river Chenab proper, has its source in the glaciers south-east of Baralacha Pass (16,200 ft) on the mountains towering up to about 20,000 ft and after flowing south just west of the Kanzam Pass (14,931 ft) for nearly 50 miles, it bends abruptly to the west. From here it follows an almost straight course north-west to the confluence. On either sides of this torrent rise peaks ranging from 19,000 ft to 21,000 ft, with gigantic glaciers, which often descend with a mighty roar into the river. At Topokoma south of Baralacha Pass and immediately after its origin, the river bed is at an altitude of about 15,000 ft. The fall in altitude is rather rapid up to Koksar, where the river flows at an altitude of about 10,300 ft, so that the current is fairly rapid. River Bhaga also has its source near Baralacha Pass, but on the northern slopes of the mountains and descends to 14,000 ft near Serai Zingzingbar. West of this point the torrent turns south-west and rapidly falls down to about 10,840 ft at Darcha and to 10,300 ft at Keylang. Four miles further west it joins the river Chandra, from where the river Chenab becomes a fairly wide current. The Upper Chenab Valley is flanked on the left by the Great Pir Panjal Range and on the right by the Main Himalayan Range. Countless torrents from both these ranges join the river Chenab throughout its course. At the southern spur of Mt Baihalijot the river turns sharply to the north, before it finally enters Jammu.

THE EXPEDITION'S ROUTE

The Expedition had originally planned to reach the main Himalayas (*vide map*) after crossing the outer Himalayan and Pir Panjal Ranges by way of the Kalicho Pass (16,000 ft). Starting from Dalhousie (8000 ft) on the Dholadhar Range, the route lies through the Khajiar Valley to Chamba and Brahmaur, thence northward up a narrow gorge, with beautiful glaciers on both sides, to Bhadra (10,000 ft) about 12 miles further. Leaving Bhadra, the Kalicho Pass is reached after a steady ascent. On either side of the pass the summits rise to nearly 19,000 ft. Beyond the Kalicho Pass on the north follows the rapid descent into the Upper Chenab Valley, somewhat to the west of Triloknath, from where we had hoped to go up Mt. Baihalijot on the Main Himâlayas. After a survey of the insect life on Mt Baihalijot (20,602 ft), we intended to proceed up the valley to the limits of Spiti and return by way of the Rohtang pass to the Kulu Valley and thence to the Pathankot railroad-head. The selection of this route was influenced by several considerations. It afforded an opportunity of studying the insects occurring at high altitudes on the Pir Panjal and also facilitated comparison between the insect life of the outer and inner valleys. It was also the shortest route to Mt. Baihalijot.

CHANGE OF ROUTE

Messrs Santokh Singh, Charley and Healey left about the beginning of May with all the stores and equipment for Dalhousie and Chamba, with a view to make the arrangements for transport, pack animals, purchase of essential staple food, etc. Enquiries revealed that owing to unexpected late snow-fall, the

Kalicho Pass was very badly snow-bound and was not yet opened up by the great annual migrations of sheep, vast herds of which are driven every year over this and the Kukti Passes to the wonderful grazing grounds on the southern slopes of the inner Himalayas, returning to the warmer outer valleys in winter. The Kukti Pass was also equally snow-bound. Both Kalicho and Kukti are impassable for anything except men on foot and sheep and each man carries approximately 5 lbs load. Adequate numbers of porters could not be had at Chamba and nearby to carry the Expedition's stores and equipment totalling several dozen maunds. The circuitous way through the Pangi Pass in the north was open, but the pack animals did not go beyond two stages and a bridge over Chenab near Kilar, washed off in an earlier flood, still remained unbuilt. After completing other arrangements at Agra, when I reached Dalhousie with my son, Mr Santokh Singh met me with the discouraging news. After brief consultations with Charley, Healey and with Sardar Pratap Singh, Conservator of Forests, I decided to start from the tail-end of our original plan and enter the Upper Chenab Valley near the source of River Chandra, after crossing the Rohtang Pass. Accordingly the entire Expedition, with all stores and equipments, returned to Pathankot on the evening of May 20th. Early next morning we started on the first stage of the long bus journey to the Kulu Valley. By midday we were in Mandi after crossing River Beas by a wonderful suspension bridge. A change of bus caused some delay, but due to the resourcefulness and tact of Mr Santokh Singh, the transfer of the stores from one vehicle to another was effected quickly enough and we were once more on the move. The afternoon we drove on the lovely bank of the River Beas on an extremely narrow road cut on a precipitous side of the hill, with the river bed to our right.

KULU VALLEY

Kulu was reached at dusk. Although lovelier than the Kashmir Valley, the Kulu Valley with its numerous beauty spots, suffers from lack of clean and decent hotels, adequate number of rest houses and tourist huts and though accomodation had been reserved for us in the Forest Rest House, when we arrived at Kulu, both this and the P.W.D. Rest House were full. After some difficulty we found quarters for the night in a vacant house. After breakfast on the morning of the 22nd of May, we met Sardar Niranjan Singh, D.F.O., to whom we had brought letter of introduction from Sardar Pratap Singh, Dalhousie. Sardar Niranjan Singh showed great interest in our plans and soon made all the necessary arrangements for our pack animals, porters, guides, transport, etc. We then proceeded to the Sub-Divisional officer, P.W.D., who gave us a detailed account of the route to Rohtang Pass and also issued permits for the use of the P.W.D. Rest Houses on the way. The afternoon and evening were spent in the bazaar on the bank of Beas, buying up "inexhaustible" stores of red rice of the Kulu Valley, wheat flour, salt, lentils, curry powder, dalda cooking-fat, kerosene oil and a great variety of other essential material, expected to last for nearly two months for the Expedition in the wild beyond. Everything was neatly packed, marked and labelled, listed and stowed away in the bus stand.

May 23rd Sunday at 3-30 in the morning we were ready for the last strip of the journey by bus to Manali nearly 23 miles away. Hardly we gulped scalding glasses of over-sweet tea at a wayside stall, when vigorous hooting announced the arrival of our bus, already loaded with the Expedition's stores. The drive through an enchantingly beautiful forest in the crisp morning air ~~was~~ exhilerating, but the dust from the road penetrated everywhere and liberally powdered us. We overtook vast herds of sheep and long trains of loaded mules on way to Keylang. Suddenly we came in sight of the snow-covered Pir Panjal Range ahead of us and the bus came to a standstill in the Forest Rest House after a gentle ascent and we all scrambled out. We were in Manali. The grounds and verandahs were soon littered with boxes containing the Expedition's stores. Mr. Charley, who was in charge of the stores, now quietly assumed charge and with incredible swiftness sorted things out, got round breakfast and issued field kit to everyone.

The Forest Rest House at Manali is located at about 6000 ft above sea level amidst the most beautiful surroundings. Everywhere were oak, poplar, cherry, apple, willow and graceful conifers. Wonderful varieties of flowers carpeted the ground. With the help of the local forest officials men were despatched to gather pack animals, a cook was also employed and given some training. The next day and the next we still remained at Manali waiting for the mules to arrive and the time was devoted to a rapid survey of the area round about. Collections of plant galls and torrential and other insects were made during these three days. Charley and Healey made friends with some Canadian Missionaries, with whom they spent a great deal of time or enjoyed themselves by going up the nearby hills and coming back thoroughly exhausted in the evening.

START OF THE TREK

The pack animals and porters assembled on May 26th and we began the long trek on foot after breakfast, nearly ten days behind schedule. Crossing Beas by a wonderful wooden bridge, we went up a mule-track on the left bank of Beas, through a forest of evergreens, collecting insects on the way. In due time near the southern slopes of Pir Panjal, in front of an enormous glacial morraine, we once again crossed to the right bank of Beas. The river was now a very narrow torrent at the bottom of a dark precipice. After about a mile, recrossing to the left bank, we slowly ascended to the Rest House at Kote (8500 ft) in the midst of a lovely deodar forest. The evening became cloudy and a high wind was blowing. We had now almost reached upper end of Beas basin. Beaskund, the source of the River, was not very far off.

THE ROHTANG PASS

At 5 next morning (May 27th) we were on the move to the Rohtang. A distance of 12 miles had to be covered and an ascent from about 8500 ft to nearly 14,000 ft, followed by nearly a mile on the summit before descent on the other side down to about 12,000 ft. The first part of the trek was almost level walk to the desolate forest hut at Rahla (9000 ft) at the foot of Rohtang. We were advised by everyone to cross the pass before 8 in the morning but our progress was necessarily very slow, owing to the need for stopping en route for collections and recording of observations. Inspite of repeated warnings that we should be over the pass before 8, we were only at Rahla by 9 in the morning. The time that was thus lost was amply compensated by the insects which we collected on the way.

Although only 14,000 ft above the sea level, the Rohtang Pass is famous for the daily fierce hurricane, which begins about 9 in the morning and continues till late afternoon, when the surface snow softens, so that the mules could hardly get a decent foothold. When we began the climb to the summit of Rohtang, the daily hurricane was blowing with full fury right in front of us; biting cold blast, cracking the skin about the nose, penetrating to the skin and impeding free and easy movement. We were overtaken by herds of sheep and mule trains on way to Keylang and soon our own pack animals passed us by. We were almost the only souls to reach the summit of Rohtang just after 1 in the afternoon under a brilliant sun. In the blinding glare we settled down on the snow to examine and partially sort out the catches of insects and eat lunch. Charley and Healey had already gone ahead of us.

Standing on the summit of Rohtang, one sees a vast desert of snow, almost level for a distance of nearly a mile. Moving north one really looks into an entirely new world—a world of unbelievable desolation and barren rock, snow and glaciers, without so much as a blade of grass, but also indescribably beautiful. Gone are the green pastures, fertile fields, lovely orchards and dense forests of the Kulu Valley and in their place is a world of glittering-white snow-capped peaks rising to over 20,000 ft above mean sea level. As far as the eye can reach, there is an unending vista of snow-covered peaks upon peaks—the Spiti Himalayas to the right, the Pir Panjal to left and in front in the north just across the Chenab Valley the Main Himalayas.

My son who was so far fresh, now began feeling the effects of the altitude, hurricane and glare, developed a slight headache and nearly lost all enthusiasm. He showed complete indifference to the beauty that abounded on all sides and was equally apathetic to the scientific zeal of his elders. As we descended, the snow-covered Upper Chenab Valley below came into view. We had 6 miles of snow yet to be covered before reaching camp. Charley had already descended into the Valley ahead of us and fixed the camp at about 12,000 ft above Koksar and was busy with preparations for tea and evening meal. Owing to the need for collecting and recording observations, we moved rather very slowly, but the last few furlongs were finished by squatting on the snow and sliding down with great speed. After crossing two difficult but wonderful snow-bridges, we finally reached camp after 5 in the evening.

During the night the temperature dropped below 34°F. Charley, Healey and my son were stiff in every limb and were in need of rest. Owing to the unusual food, Mr Healey's digestion was also troubling him. I left them to rest and amuse themselves as they liked in the camp and went out with Santokh Singh on the morning of the 28th. In the cheerful morning sunshine we beheld a scene of enchanting beauty and serenity. Right in front across River Chandra rose the main Himalayas sheer 9,000 ft above the river bed. The valley here is itself about 12,000 ft above sea level. Everywhere around us, Nature had spread a marvellous carpet of lovely Himalayan flowers, tiny, delicate, rose, pink, red, orange, lilac, blue, yellow and white, right on the edge of snow and reaching up to 14,000 ft. I spent the day collecting insects, pressing plants, taking close-ups of the flowers in kodachrome, recording observations of temperature, pressure, currents, etc.

THE TREK THROUGH THE UPPER CHENAB VALLEY[1]

On May 29 the whole party was on the move down the valley at 9-30 in the morning. The pack animals proceeded ahead with Charley and Healey on to the next stage nearly 8 miles away, below Yangling. Crossing River Chandra by bridge below Koksar, we trekked on the right bank of the river and crossed several glaciers and snow bridges. Three miles after the start, a halt was made at a torrential stream for collections. We were now at about 11,500 ft. After considerable time, we proceeded up a gentle ascent to nearly 11,700 ft and camped in the P.W.D. Rest House at Sissu below Yangling. The Pir Panjal Range opposite our camp rises clean by 9000 ft above the river bed level like almost a rugged perpendicular rock wall and we get most magnificent views of Mt Garpang (19,000 ft) and Mt. Shikar Beh (20,340 ft). An enormous fall of powdery snow and water, mixed with loose stones, was thundering down a perpendicular precipice into a cup-like depression nearly 500 ft below on the other side of the river. Leaving Sissu camp on May 30th, we ascended to over 12,000 ft, after crossing an enormous torrent coming down from a glacier (21,000 ft) on our right above. Our next camp was at Gondla 8 miles off. In front of Gondla the Pir Panjal rises as a colossal precipice to over 20,000 ft, with two enormous glaciers on the top, portions of which constantly break and come down as great avalances into the valley below. At Gondla there is a curious wind-mill shaped castle of the Thakur of the Lahoul valley.

From Gondla the route lay over a gentle ascent to a little over 11500 ft and round an abrupt bend to the north descended once again to the river bed. Near this bend is the track to Asa Gali Pass on the left bank of the river. At the end of the descent we were at the confluence of the rivers Chandra and Bhaga. Crossing the river Bhaga by a suspension bridge the road to Keylang lies on the right, but we turned left and followed up a fairly hard ascent to 500 ft to camp above the village Tandi (May 31). Thirot was reached on the afternoon of the 2nd of June and camp was established in a small newly planted willow clump near the river. The route beyond lies over rather very rough and difficult ground, with frequent landslides, loose stones, and debris over which loaded mules are not driven with safety. Everything had therefore to be transported by means of porters. The boxes were repacked, with the stores divided and the load in each case carefully adjusted. The heavier stores, the collections already made and some part of the food reserves were left behind and only the absolutely essential stores and equipment were carried with us. A number of sturdy Lahoul girls were also engaged as porters for one stage further. On the morning of the 3rd of June, after very considerable delay, owing to the porters trying out the loads and necessitating readjustments, we got going and crossed the stoeam that forms the border between Chamba and Punjab. To begin with, the route was almost on level on the sands of the river Chenab and progress was difficult in the heat and glare. The weather was still exceedingly fine with a brilliant sun in a cobalt-blue sky. Then came a slight ascent and beyond a descent down a narrow track on a precipitous rock down to the cantilever bridge of timber on the river. Crossing the river we were in a shady and cool coniferous forest on the left bank and from now on there was climb up to Triloknath, where we camped in the large village green in front of the temple and a few mud and stone huts, perched at the edge of a cliff rising clear 1000 ft from the river. Above us to the left was the Kalicho Pass.

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[1] *Vide* Borradaile, J. W. 1927. *J. Bombay Nat. Hist. Soc.*, **32** : 163-168, for brief account of his travel in parts of the Lahoul Valley.

ON MT. BAIHALIJOT

June 4th, the next day, was my son's 17th birthday. Mr Healey woke up with bad digestion and my son had a slight cold. We had difficulty with the porters. Half of them including the girls, refused to go further and wished to be paid off. Fresh arrangements and readjustments of the loads delayed our departure but at last we descended once again to the river and crossed over to the right bank. We were now in the Miyar Valley. We crossed Miyar at noon and were on Mt. Baihali. Ascending to over 9500 ft we entered dense coniferous forests. Turning round a spur and slowly ascending, we were greeted by a strong hurricane and dense floating clouds. Progress now became slow. When we reached Namu gorge at 4 in the afternoon the hurricane abated somewhat and clouds also cleared. As we had originally planned to go to the summit by way of the gorge, we swerved to the right and proceeded up in the direction of a glacier. The clouds reappeared, so also the wind and rain fell. Fresh snow started falling above. A hurried search revealed a sheltered spot besides a cluster of stones for the camp. Almost everything was wet. Arranging the boxes round the tent to break the wind we crawled into our sleeping bags. The porters preferred going down to Margran near the river Chenab below.

The 5th of June day break was calm and clear. The porters, not so far aware of our plans of going up to the summit, now began to have vague suspicions. I sent Santokh Singh, Charley and Healey up the Namu Gorge to the glacier immediately above us to look for a possible easy way to the main peak. They left soon after breakfast and a little later clouds appeared and nearly blotted out everything. The porters were told to rest. I remained in camp with my son and cook and together we set about arranging things. We were in a sort of cup-like depression and the surrounding ridges hid everything beyond. Time dragged heavily on. When the advance party came back after midday with information regarding the route up to the summit, the porters became openly hostile. They flatly refused to carry the stores and equipment higher up and near enough to the summit to enable a final assault in clear weather. We tried arguing and tempting them with heavy bribes, almost beyond our means, and even quadrupled their wages, with promise of further generous tips on return. Nothing could however induce them to change their attitude. They objected to the Englishmen going up to a holy place. They were horrified at the idea of going to the summit with our leather shoes. The summit of Baihali is the abode of gods and goddesses and it is sacrilage to intrude on their privacy. One often reads about the proverbial superstition of the hill folk, but here we were face to face against a combination of fear, superstition, unreasoning obstinacy and tradition, far out in the heart of the Himalayas, over 120 miles from science and civilization. I realized that reaching the summit was impossible unless we could have tent, sleeping bags and sufficient stores of food for at least five days at a higher camp. Transporting these essentials was now not possible. Differences also arose among the members of the expedition. Santokh rightly recognized the impossibility of moving up further to establish a higher camp unless the porters co-operated. Mr Charley however decided that he would himself carry sufficient stores. Plainly he underestimated the magnitude of the task he had made up his mind to carry out. Mr Healey had no choice of his own and Charley had decided for him. The stupidity and fear of the porters annoyed my son equally. Mr Charley insisted on making an attempt under any circumstances. I tried my best but failed to convince them of the impossibility of reaching the summit under such conditions. Accordingly, the stores were divided and generous supplies of tinned stuff were laid out carefully: Mr Charley's plan was to avoid the gorge altogether, because of its distance, and go up the ridge below which we were camping. It had the virtue of being shorter but beyond on the other side the going was most difficult. He hoped to reach near enough to the summit in three or four days and we were to wait in camp below. Charley and Healey left in the afternoon with some stores, which they carried up to nearly 600 ft above and left in a sheltered spot on the ridge and came back to camp for the night. As next day Healey was indisposed, nothing further was done that day. Early on Monday the 7th of June when everyone else was still sleeping, Charley and Healey crept out of their sleeping bags and prepared for the climb. They had their sleeping bags out, a cooking stove and food stores and carefully packed everything, adjusting the load with great deal of thought and discussion. I made coffee and saw them off beyond the nulla and up the ridge. The sun arose an hour later and we all watched the two tiny figures going slower and slower, up and up on the ridge till they vanished beyond the clouds at about 600 ft above our camp.

The day was one of anxiety for safety of Charley and Healey, gone out on a task which we fully knew to be quite beyond their capacity. They were carrying loads of about 50 lbs on a ridge, the ascent of which was by no means easy because of loose stones, fresh snow and wind. Further they had no tent. Soon they came to difficulties. They slipped and lost practically everything but only a miracle saved them. Realizing now the utter impossibility of reaching anywhere near the summit, they limped back into the camp hungry, exhausted and sore in almost every bone at 8 in the evening, when we were settling down to our meal. Mr Healey was almost on the point of collapse. We revived them with hot drinks and liberal doses of glucose. We were glad to have them back in the safety of the camp.

The summit presented several interesting features: it was not merely the the altitude but also other unique conditions depending on the position of the mountain considerably increased the interest and importance of collections of insects from the summit, provided it had been possible for us to reach it. Owing however to the impossible conditions—the superstious fear and hostility of the porters, the inability to transport stores to camps higher and nearer to the summit—I decided with great disappointment and to the annoyance of almost everyone to abandon the attempt on the summit. There was nothing that we could do now and accordingly I gave orders for the return. Late on the morning of the 8th the porters once more moved slowly down with the load and the camp was broken. We were once again in the valley below and reached Thirot on the 9th and despatched a porter in search of the mules. The majority of the porters were paid off and the trek back with the mules began on the 10th and we returned to the confluence of Bhaga and Chandra in due time. Charley and Healey went up to Keylang to witness the annual devil dance of the lamas and the rest of us moved on to Gondla. Koksar was reached on the 14th and the Rohtang Pass was recrossed on the next day. The entire party arrived at Manali early in the forenoon of 16th. We had altogether covered over 200 miles on foot on the Himalayas and had never once been below an altitude of 9000 ft.

STORES AND EQUIPMENT

It may perhaps be assumed that an expedition to the Himalayas would involve enormous sums of money, complicated equipment and great deal of organization quite beyond the means of many. While this is certainly true of expeditions to some of the great peaks, even a small expedition to any of the numerous smaller mountains, without very costly equipment, can hope to reach previously unexplored regions and discover an entirely new world of insects. We carried from Agra nearly everything that was likely to be required, but we obtained supplies of potato in most of the villages through which we passed in the Lahoul valley. Our stores comprised in addition to essentials, considerable quantities of tinned food materials, kerosene oil for fuel and a great variety of other things. The medical stores included bandages, vitamins and drugs for cold, pneumonia and a variety of ailments. We had besides tent; sleeping bag, wind-proof suits, hiking and climbing shoes, ropes, sticks, goggles as protection against glare from snow. The more important among the scientific equipment were thermometers, barometer, compass, maps, telescope, cameras and accessories such as stand, close-up attachments and telephoto, yellow and polarising filters,* developing tank and developing chemicals done as correctly weighed out powders ready to be dissolved, killing bottles, jars, tubes, labels, pampel's fluid, spirit, formalin, paradichlorobenzene, small sieves, vasculum, plant press, packing cloth, etc. We had several hundred feet of black-and-white and kodachrome 35 mm film. We did not carry oxygen or other complicated alpine equidment. The stores were packed in light wooden boxes, small and light enough to be carried by a single porter at high altitudes. The boxes were numbered and every member of the Expedition carried complete lists of the contents of all the boxes to avoid difficulties in an emergency.

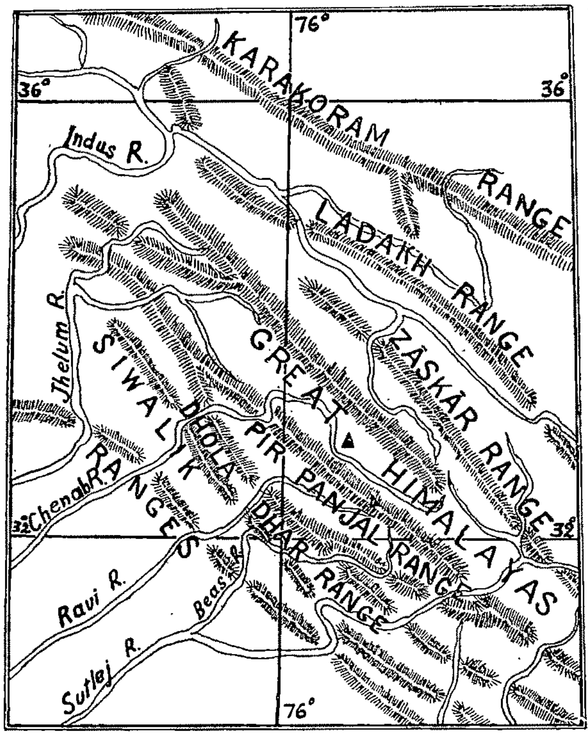

FIG. 1. Sketch map of the part of the Himalayas visited by the Expendition, to show the series of ranges and valleys. The Expedition was on the southern side of the Great Himalayan Range.

LIFE IN CAMP

The life in camps was on the whole comfortable, though on occasions somewhat crowded. Although there were no serious shortages, food was one problem that worried Messrs Charley and Healey. Not accustomed to the kind of food, they tried to supplement by personal researches into cookery. Healey never generally ate his fill for fear of upsetting his stomach, but Charley compensated for everybody. We often enjoyed the Tibetan tea with the porters and mule men. It was my special job to wake up everyone with coffee in the morning. Charley and Healey stayed an hour behind to help packing and loading up mules, but nearly always overtook us en route and proceeded ahead to establish the next camp. In the evenings we sat down sorting out the collections, completing field notes and discussing plans for the next day. Whenever we camped near a village or other than human habitation, we had heavy demands for empty cans and our camp was also turned into a medical unit.

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*I did not use ultra-violet filters.

GENERAL OBSERVATIONS

The Expedition came across an amazing variety of insects, the great majority of which are new to science and are now in the hands of specialists. While detailed descriptions of the species and full reports of the results of the Expedition's work will not be ready for some time, attention may howeuer be drawn here to certain interesting features of the insect life of the Himalayas and the unique conditions under which the insects occur.

Nearly all the orders of insects with which we are familiar on the plains also occur in the Himalayas, but certain specialized orders predominate. Certain forms occur exclusively in the inner Himalayas. In the outer valleys, for example, there is a great preponderance of largely tropical and sub-tropical forms of Orthoptera, Lepidoptera, Homoptera, Hemiptera, Coleoptera, Odonata, bark-boring Hymenoptera, *Bremus*, Cynipids, etc. The inner valleys are inhabited exclusively by Ephemerida, Plecoptera, Trichoptera, Dermaptera, Odonata, aquatic Diptera, caverniculous Coleoptera, Collembola, etc., with characteristically temperate or arctic facies. The order Dermaptera is for example repre-

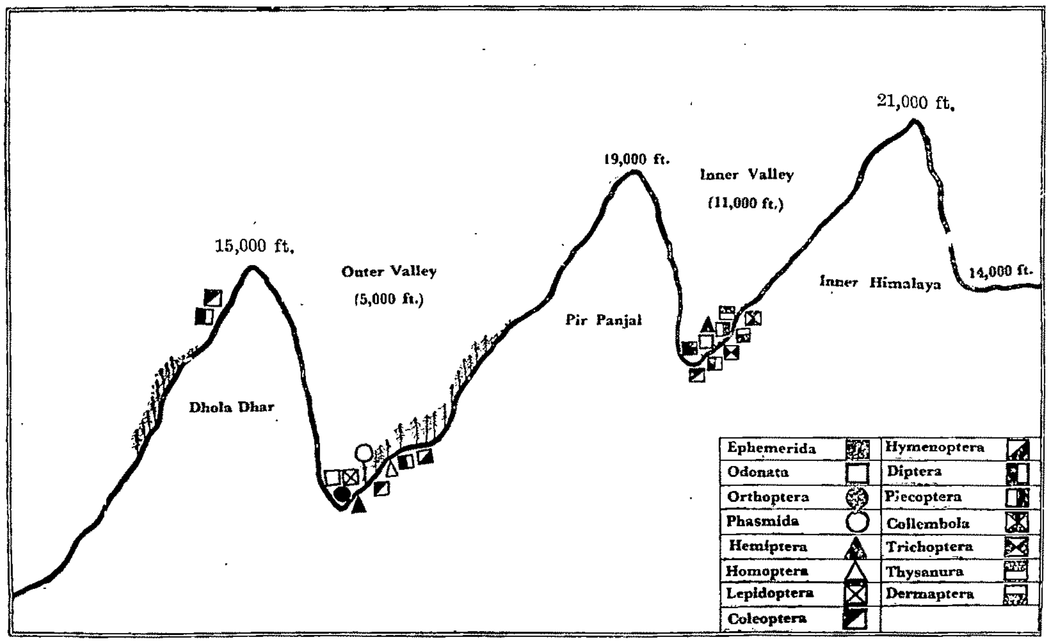

FIG. 2. Diagrammatic section of the Himalays surveyed by the expedition.

sented by typically mountain-inhabiting *Anechurinae*, specimens of which were collected at the highest altitude so far recorded from the world for this genus.[1] The insect life of the outer valley is thus conspicuously different from that of the inner valley. The outer valley lies between the Dholadhar and the Pir Panjal Ranges and the inner valley between the latter and the Main Himalayas and is the Upper Chenab Valley (Fig. 1). In the outer valley preciptitation is copious both as rainfall and winter snow but the monsoon does not penetrate the inner valley, which is therefore relatively dry. The torrents in the outer valley are largely rain-fed, but those of the inner valley arise from glaciers. The vegetation of the inner valley is characteristic of the Tibetan and Central Asian regions. There is relative deficiency of oxygen in the atmosphere, but the torrents contain a comparatively abundant supply of dissolved oxygen. Glare, radiation especially the ultra-violet part of the solar rays, cold dry winds, relative scarcity and lack of variety of food, restriction of the feeding period to the short summer are some of the other important factors which determine the distribution of insects. Dry barren rock, damp or moss-covered rock, snow fields, glaciers, streams, torrents and caves are some of the more important habitats, with specialized insects characteristic of each.

The former belief that insects and other lower animals are not affected by the extreme conditions of the high altitude in the Himalayas is wholly erroneous. A remarkable variety of adaptations are met with and wholly unrelated insects occurring in similar Himalayan habitats exhibit strikingly same adaptations. Owing to the relative oxygen deficiency of the atmosphere and the comparative abundance of the gas dissolved in the water of the torrents, the great majority of the insects occurring in the Himalayas are aquatic and actually inhabit the torrents. This refers not only to the primarily amphibiotic forms like Ephemerida and Plecoptera, but also to others like Coleoptera, Diptera, etc. The dominance of aquatic forms becomes specially conspicuous as we go higher and deeper into the Himalayas and is undoubtedly an adaptative feature. The insects occurring in the Himalayan torrents, especially in the inner valley, exhibit an astonishing variety of adaptations for anchorage to submerged stones, boulders, etc. The torrents also contain a relative abundance of food supply in the form of algal slime, and this is another factor which also explains the greater abundance of insects in the torrents than on barren rock or in crevices. The bulk of the species are debris or carrion feeders, scavengers and predators; truly phytophagous species are scarce. A striking feature of the insect life of the inner Himalayas is the greatly prolonged larval life, with hibernation and diapause, with correspondingly short imaginal period, which is also restricted to the brief summer. Emergence of the imago usually takes place in the afternoons. Several species are nocturnal and exhibit typical caverniculous features. Low temperatures do not seem to prevent the activity of insects, which move about freely on the snow both during the day and at night, burrow in snow and actively wriggle or swim in water at 4 C. Gigantic swarms of the Collembola, *Podura himalayana*

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[1] *Vide* Santokh Singh, 1955. *Agra Univ. J. Res.*, (Sci.) **4** (1): 179.

Baijal,[1] impart a sooty-black colour to vast patches of snows and glaciers above 15,000 ft. Small coprinini roll balls of sheep dung on snow-fields, dig in the snow and bury in deep-seated blood chambers.[2]

In 1914 Guy Babault[3] of the Museum National d'Histoire Naturelle, Paris, travelled extensively in the Western Himalayas and collected a great variety of insects from some parts of the Upper Chenab Valley surveyed by the Expedition. In addition to collecting some of the insects recorded by Babault, the Expedition also came across several other remarkable forms. In another Expedition during the coming summer (1955), it is proposed to survey the area to the east up to the shores of the salt-water lake Tso-Morari.

All the collections of insects will ultimately be deposited in the National Collection of the Zoological Survey of India, Calcutta and will thus be available for future students.

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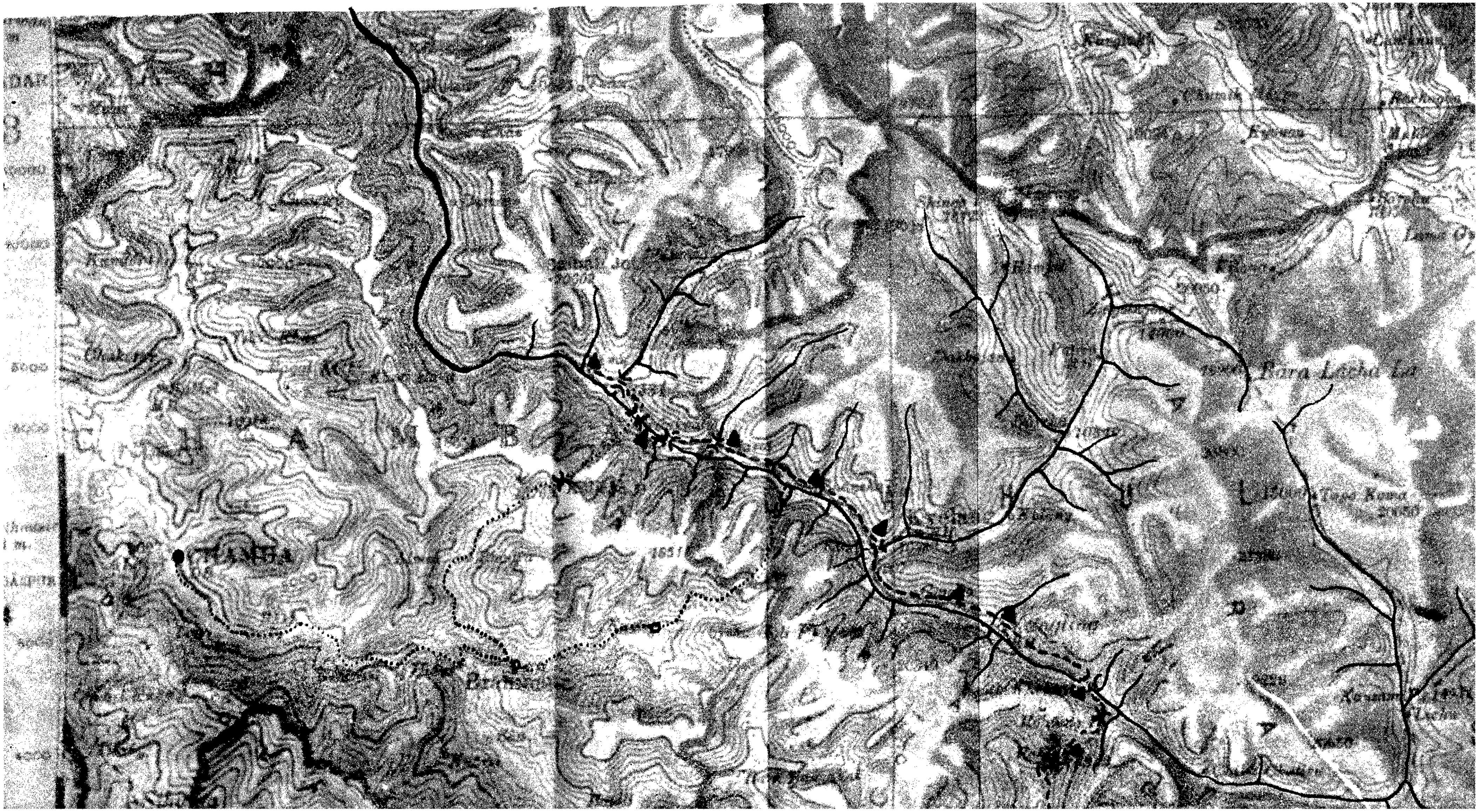
[1] Baijal, H. N. 1955. *Agra Univ. J. Res.*, (*Sci.*) **4**: 175.

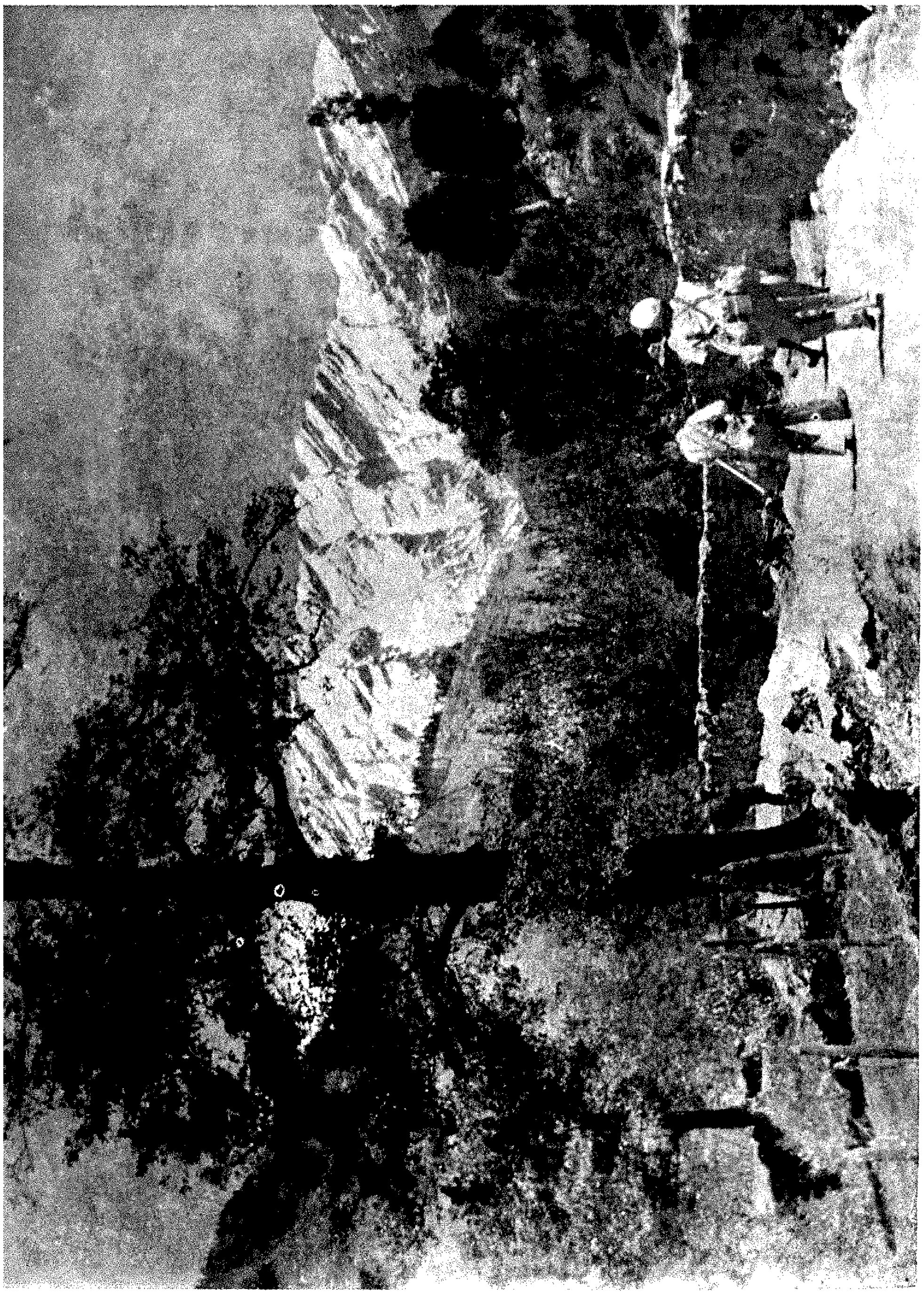
[2] Hingston (*Naturalist in the Himalayas*) also records observing the dung-rolling activities of these beetels in the cold, dry and inhospitable heights in the Himalayas, but not on snow-fields.

[3] Babault, Guy. Mission dans les Provinces Centrales de l'Inde et dans la Region Occidentale de l'Himalaya 1914. Resultats scientifiques—Insectes Coleopteres: Histeridae by H. Desbordes (1921); Carabidae by H. E. Andrews (1924); Orthoptera by B. P. Uvarov (1925); Curculionidae by A. Hustache (1928), etc.


CHAMBA
Bara Lacha La

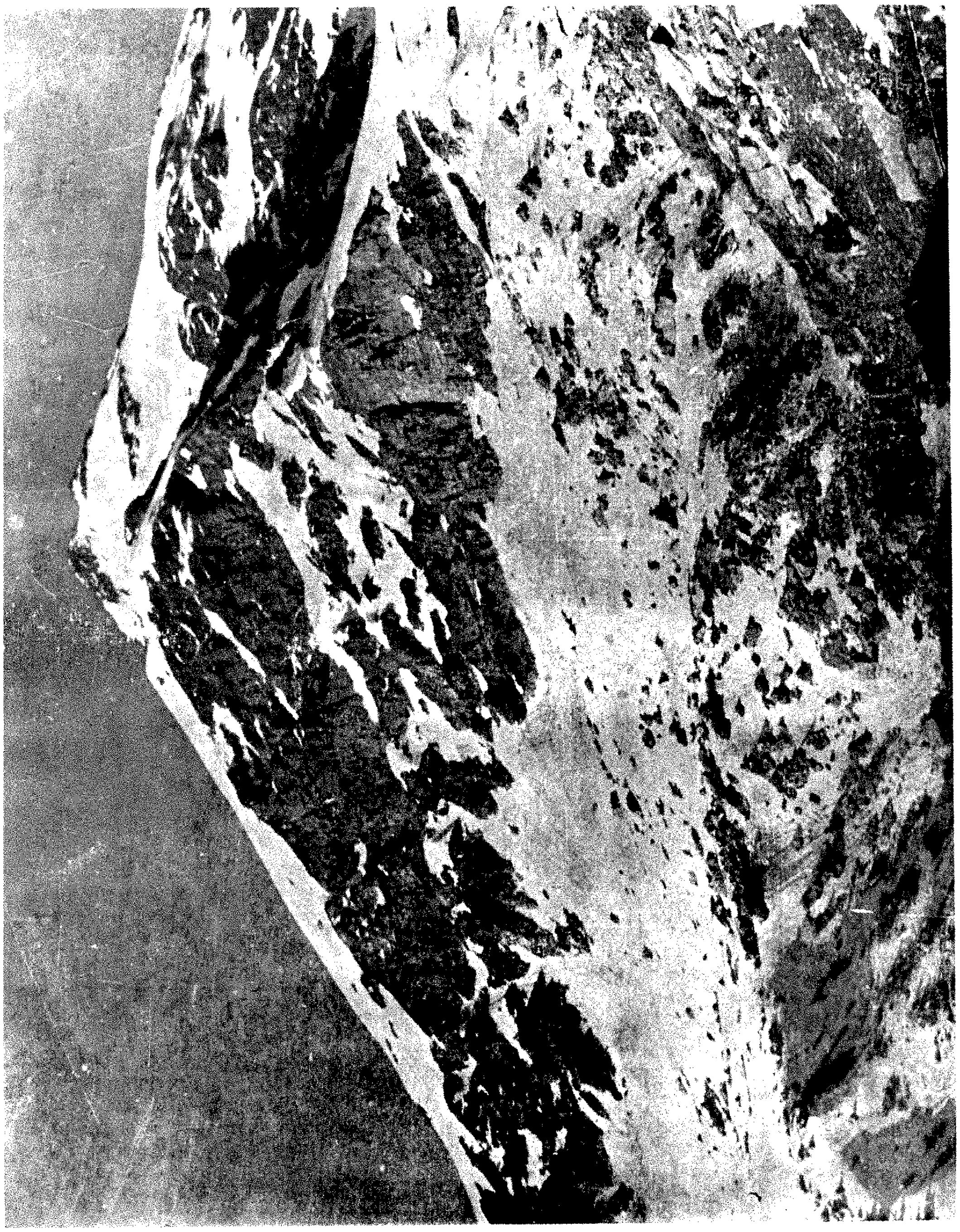
To face p. 170

Plate II



The Great Pir Panjal Range at the end of the River Beas Basin—On the other side of the snow-covered hills is the Upper Chenab Valley.

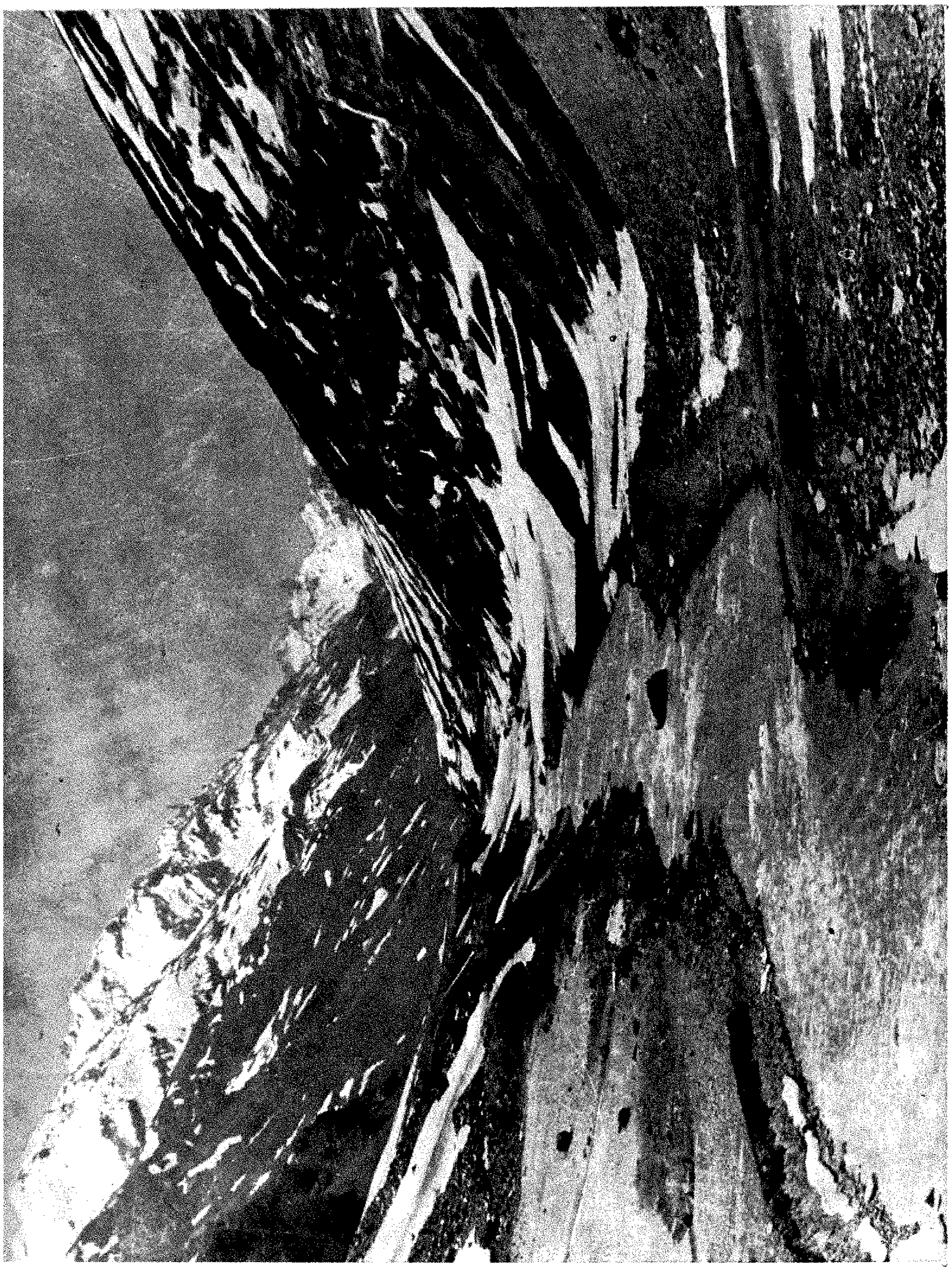
Plate III



The Great Pir Panjal—north aspect—16,000 ft. On the glaciers were collected Collembola. Swarms of Ephemeride were seen near the glaciers at 1 o' clock in the afternoon.

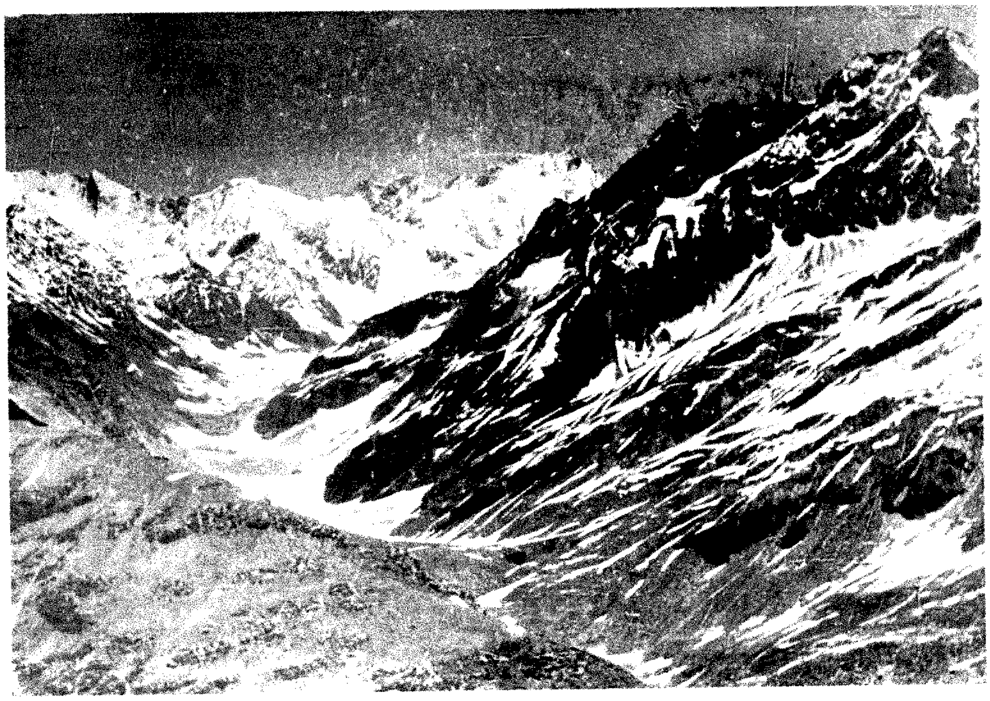
To face p. 170

Plate IV



A view of the snow covered Upper Chenab Valley, with Great Himalayas on left and Pir Panjal Range on right, Spiti Himalayas in the background; in the foreground is R. Chandra.

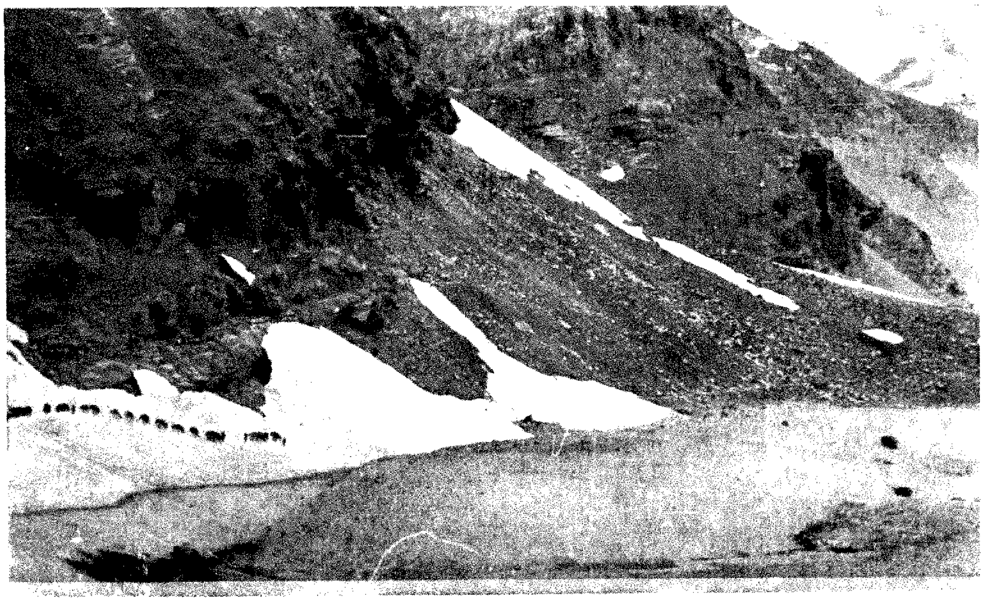
Plate V



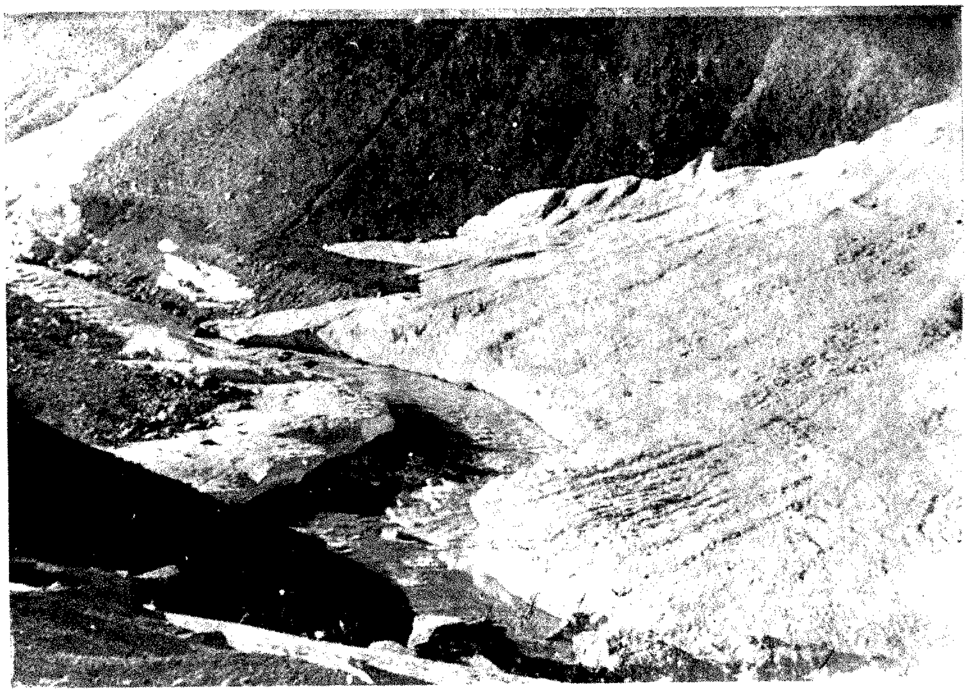
A view of the glaciers on the Great Himalayas: Upper Chenab Valley, facing Spiti side, vast stretches of the glaciers appear sooty-gray owing to gigantic swarms of *Podura himalayana* Baijal. Average altitude 18,000 ft.

Upper Chenab Valley west of Koksar

Plate VI

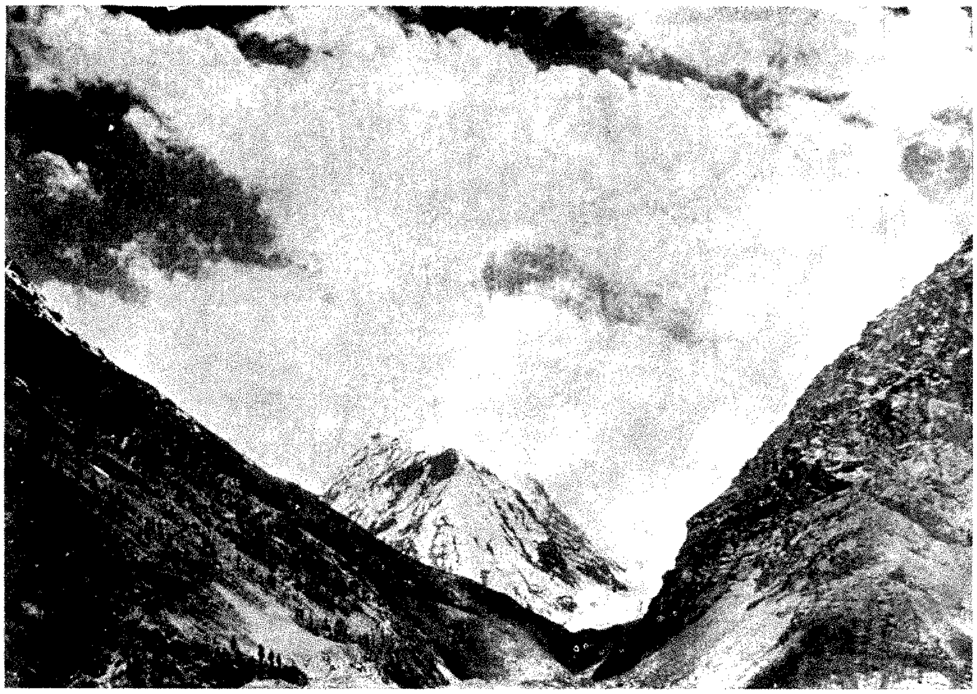


The Expedition's pack animals and porters crossing a stretch of snow in the Upper Chenab Valley.

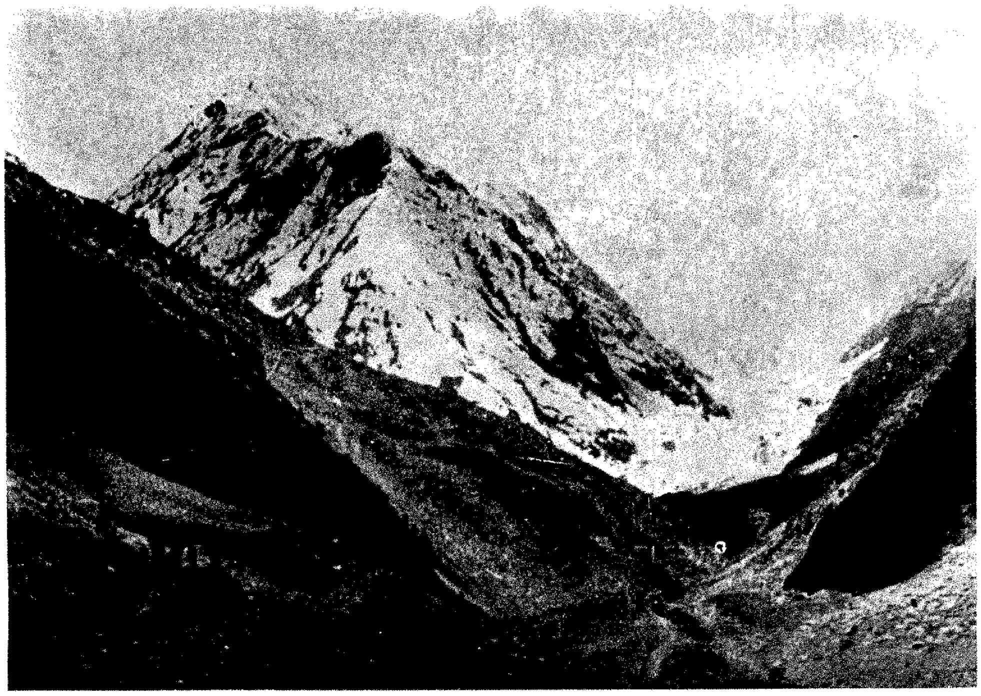


A glacier from the Great Himalayas descending down to the bed of R. Chandra

Plate VII

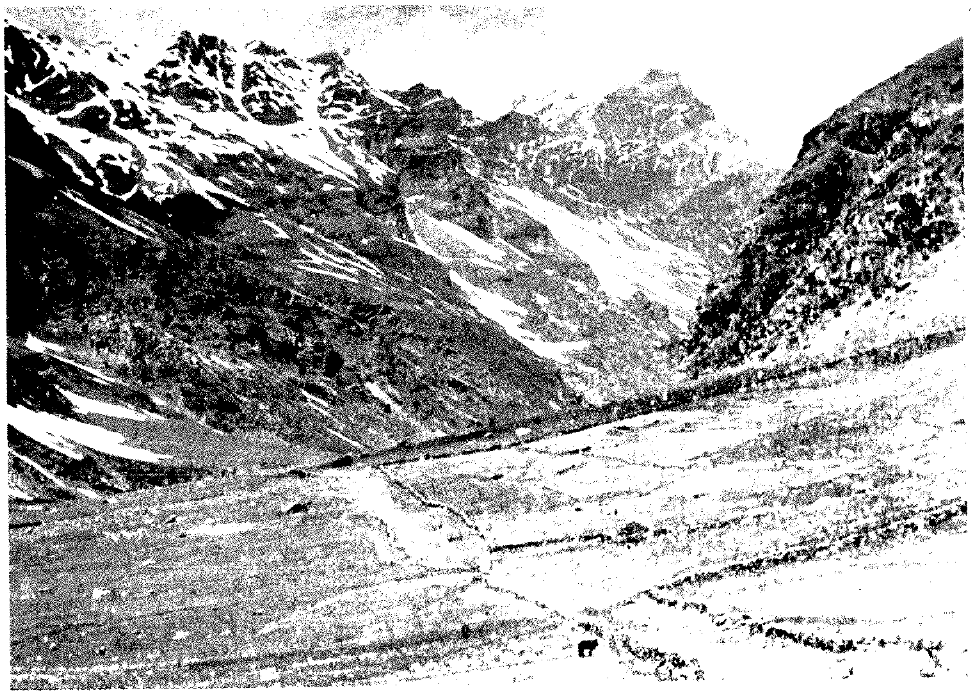


Mt. Garpang 19,000 ft., viewed from the Great Himalayas across R. Chandra.

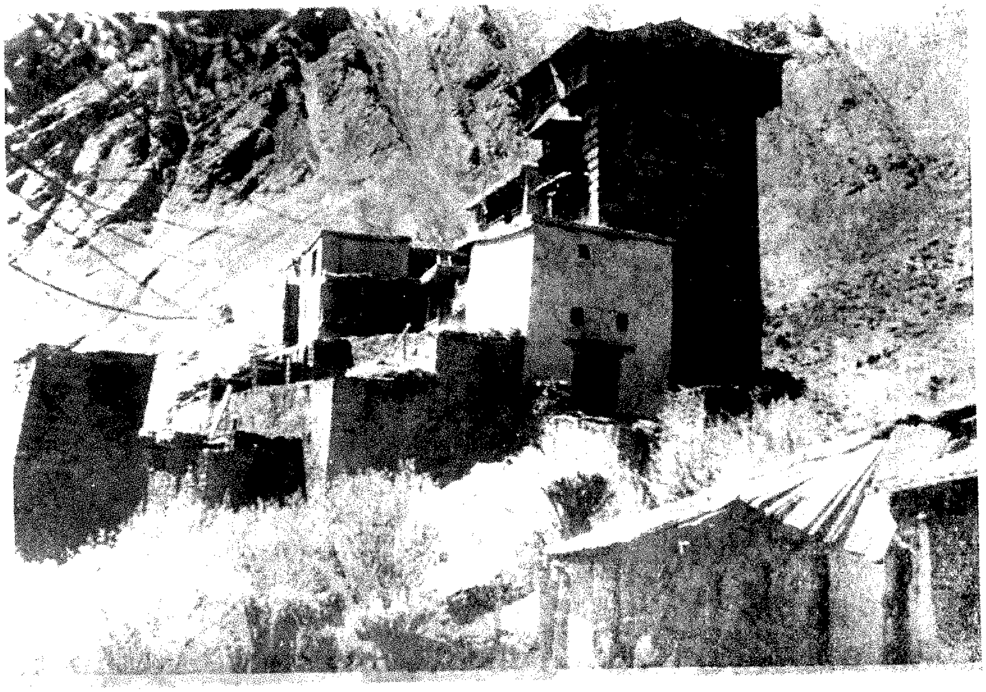


At the base of Mt. Garpang.

Plate VIII

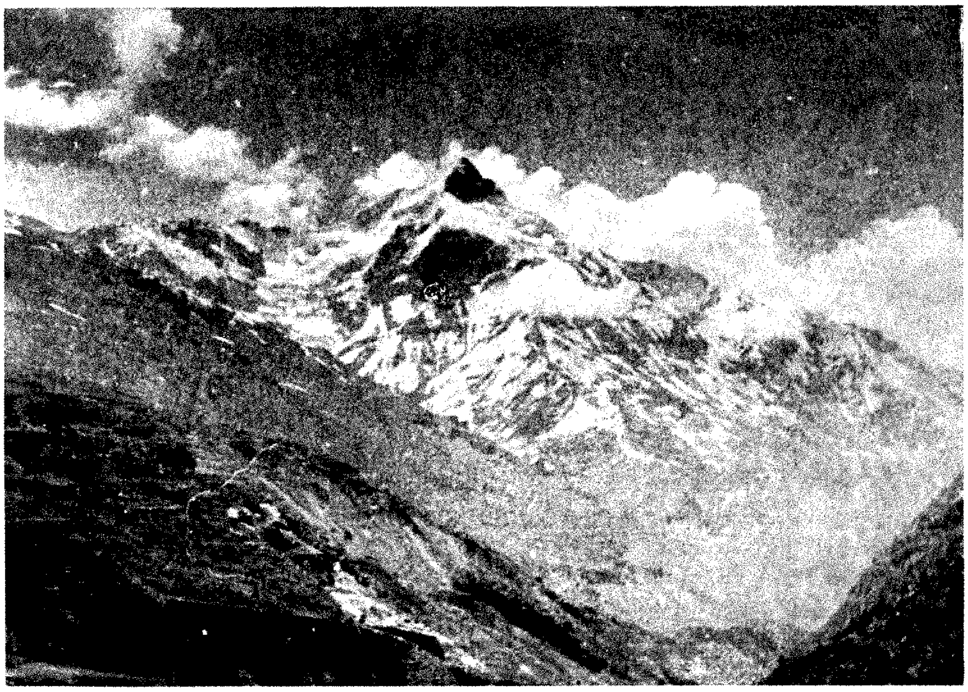


Upper Chenab Valley, near Gondla.

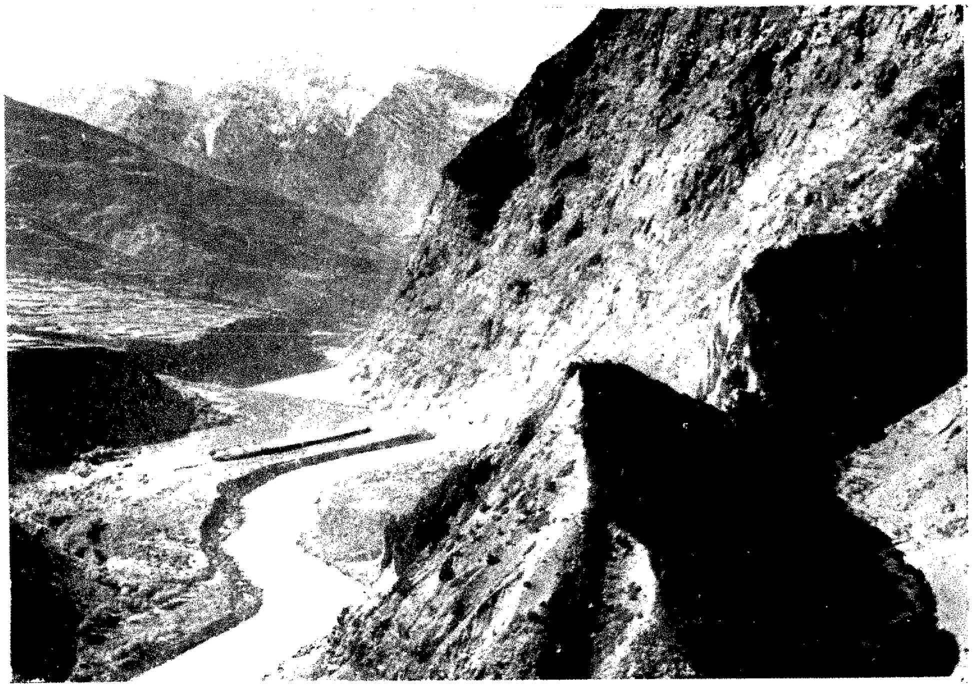


Gondla: the curious windmill-shaped Castle of the Takhur.

Plate IX



A part of the Great Himalayas, looking up the Upper Chenab Valley.



River Chenab near base of Mt. Garpang.

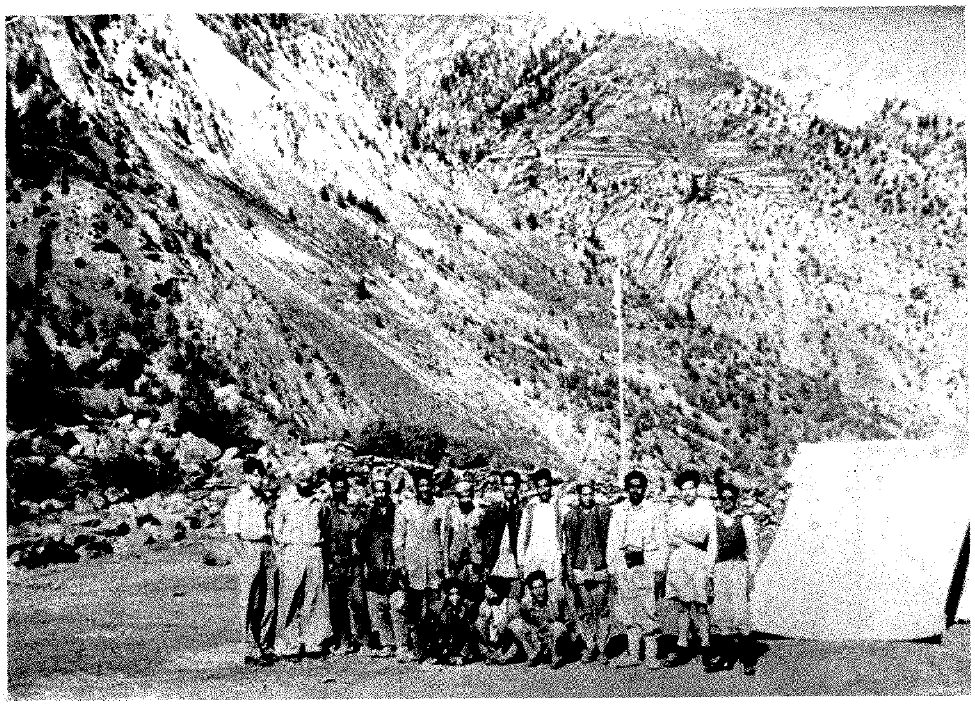
Plate X

Main Himalayas, with Mt. Baihalijot, from Triloknath.

The twin peaks of Mt. Baihalijot, rising to 20,602 ft, viewed from Chenab Valley; north-eastern slope, with frequent cold dry winds and avalanches.

To face p. 170

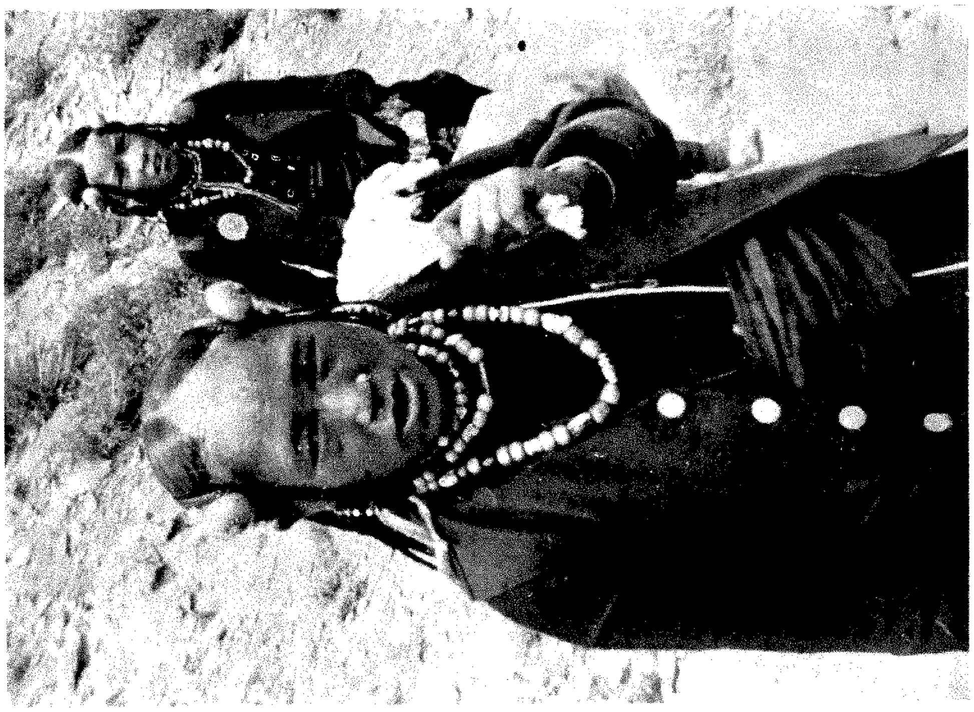
Plate XI



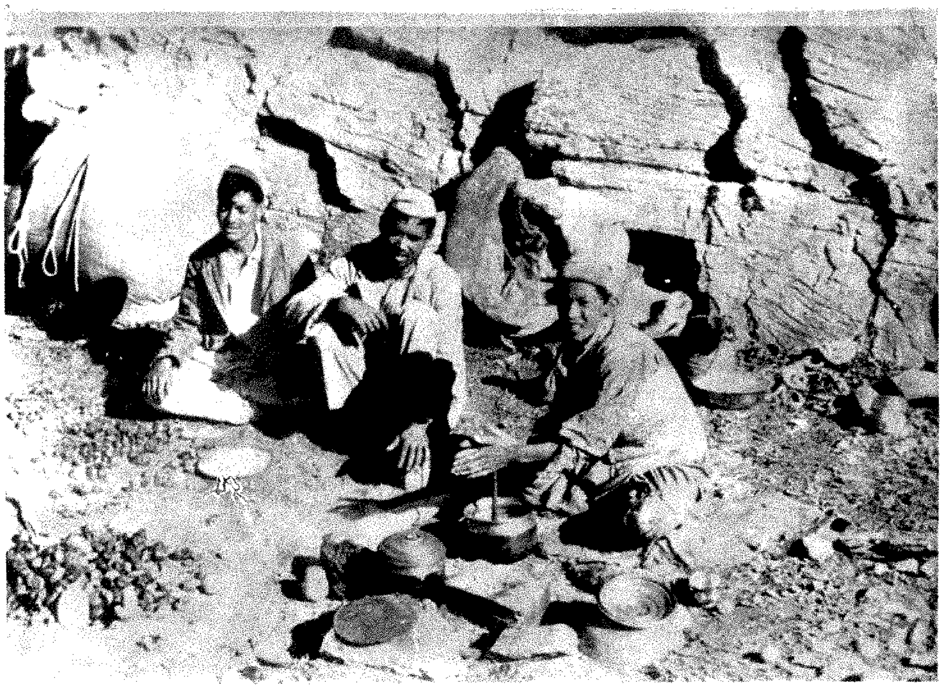
The Expedition at Triloknath, with some of the porters who carried the equipments and stores On extreme left are Messrs Healey and Santokh Singh and on the extreme right Mr. Charley and Master Mani.

Some of the porters who accompanied the Expedition on Mt. Baihalijot, but later refused, on grounds of superstition, to go up to the summit.

Plate XII



Women of Lahoul Valley are of sturdier build than men and do all the work at home and in field. Among the Expedition's, porters there were some women also. They wear enormous beads on forehead as ornaments.



One of the Camps at the edge of an enormous glacier. On left Dolaram, the Expedition's Cook and in the middle Puranchand, in the charge of peek animals, preparing Tibetan tea in the evening. Note mule dung pellets on left in foreground for use as fuel.

To face p. 170

Plate XIII

Great Himalayas: One of the peaks reaching to nearly 19,000 ft. On this glacier many Collembola were collected.

One of the numerous glacial torrents, in the treeless zone of Great Himalayas, with the temperature of water varying between 8 C and 4 C. Such torrents are the homes of planarians, Plecoptera, Trichoptera, Collembola and Sphemerida. Average altitude 16,000 ft. Several such torrents feed River Chandra.

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS[*]

PART V.—ON TWO NEW SPECIES OF ODONATA

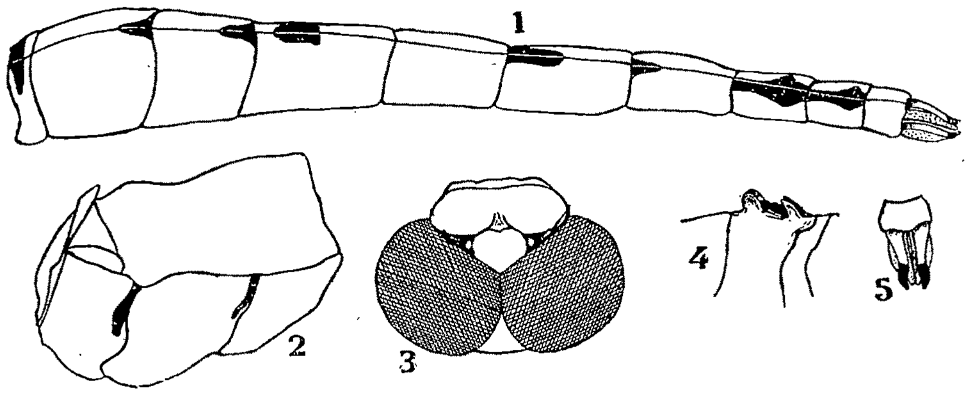
By SANTOKH SINGH, M.Sc., *Research Associate, School of Entomology, St. John's College, Agra.*

The type specimens of the new forms described here are deposited in the collections of the Zoological Survey of India, Calcutta. I thank Prof. Dr. M.S. Mani for placing this interesting collection at my disposal and for guidance.

Suborder ANISOPTERA
Superfamily LIBELLULOIDEA
Family LIBELLULIDAE

Sympetrum tandicola, sp. nov.

Male.—Abdomen 29 mm. Hind wing 40 mm. *Head:* Labium yellow; labrum yellow with black distal margin; clypeus orange with sides light yellow; frons yellow, hairy and rather prominent; vesicle small, slightly notched above; eyes somewhat contiguous and brownish; occiput small, pale yellow. (Fig. 3). *Prothorax and thorax:* (Fig. 2) Prothorax yellow with black anterior margin, fringed with hairs. Thorax yellow; humeral and postero-lateral sutures narrowly black; beneath yellow with black spots near the sutures. *Legs* black with flexor surfaces of all the femora light yellow. *Wings;* Large, bases tinted with ambre yellow; nodal index, fore wing 13½/8; hind wing 8/9-10; pterostigma yellowish brown, four times as long as broad; discoidal cell in fore wing narrow and traversed, that



Sympetrum tandicola, sp. nov. Male: Fig. 1. Abdomen. Fig. 2. Pterothorax. Fig. 3. Head. Fig. 4. Genitalia. Fig. 5. Anal appendages.

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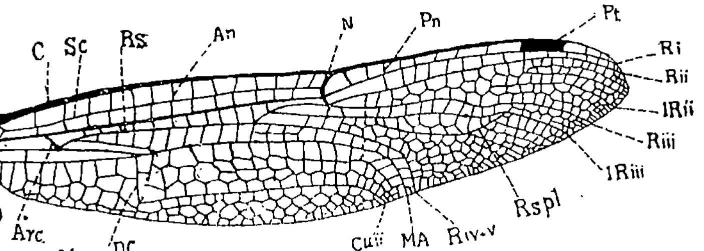
[*] Contribution No. 53 from the School of Entomology, published with the permission of the Professor of Zoology and Entomology.

of hind wing entire; sectors of arc shortly fused proximally; distal antenodal nervure incomplete; Cu_{II} arise from the posterior angle of the discoidal cell; discoidal field with three rows of cells, its sides converging strongly at the wing border in the fore wing; two rows of cells between IR_{III} & Rspl; membrane medium sized and pale yellow. (Figs. 6 & 7). *Abdomen:* slim, triquetral in section yellow with black markings on the dorsal side, deep yellow towards the distal end (Fig. 1). Anal appendages brownish with tips black and slightly curved, (Fig. 5); genitalia as in fig. 4.



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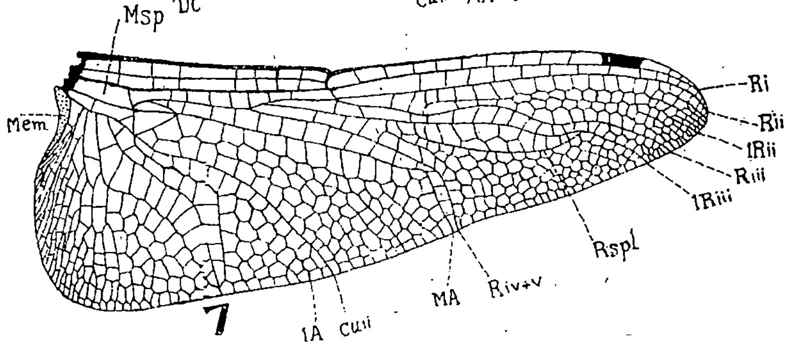

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Sympetrum tandicola, sp. nov. Male: Fig. 6. Fore wing. Fig 7. Hind wing.

Holotype 1 male in an envelope labelled, "Near Tandi, 11,000 ft., Upper Chenab Valley, Himalayas; Coll. M.S. Mani & Santokh Singh, 1. vi. 1954; School of Entomology Expedition to the Himalayas 1954."

This species differs from *Sympetrum commixtum* (Selys) group of species[1] known already from India, to which it has superficial resemblance, in the following:—The flexor surfaces of femora yellow; different index of antenodal and postnodal nervures in both the wings; in the colouration of the lebrum and rest of the head; thorax being yellow predominently; legs not entirely black; abdomen not red and brown, and in the genitalia.

Suborder ZYGOPTERA

Family COENAGRIDAE

Subfamily Lestinae

Lestes manaliensis, sp. nov.

Male.—Abdomen 34 mm., Hindwing 25 mm. *Head:* Labium, labrum

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[1] SELYS, 1884. *Ann. Soc. Ent. Belg.,* **28** : 38 (*Diplax commixtum*); FRASER, 1936. Fauna Brit. India, Odonata 3 : 372 (*Sympetrum commixtum*).

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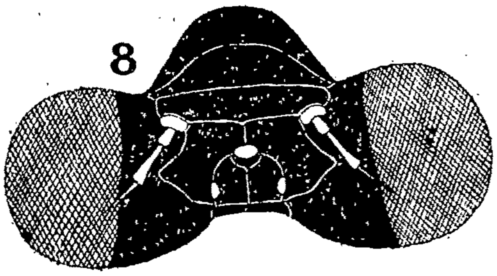

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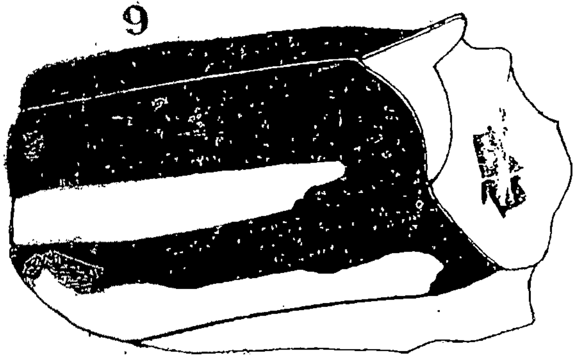

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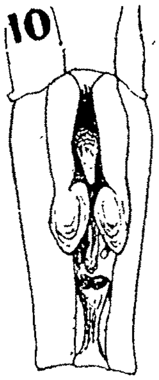

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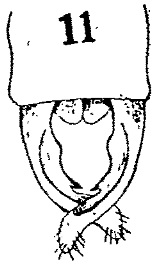

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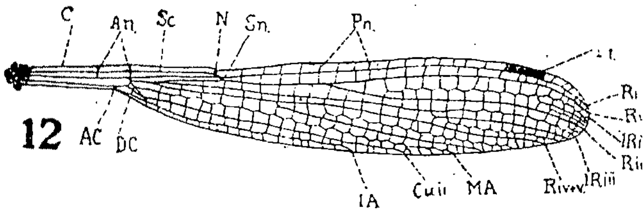

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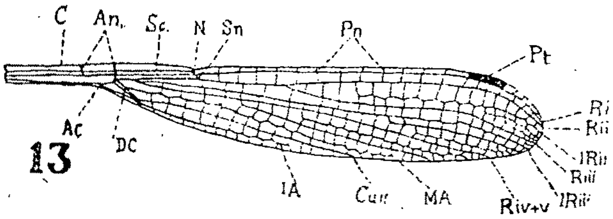

Lestes manaliensis, sp. nov. Male: Fig. 8. Head. Fig. 9. Pterothorax. Fig. 10. Genitalia. Fig. 11. Anal appendages.. Fig 12. Fore wing. Fig. 13. Hind wing.

pale yellow; mandibles dark brown; clypeus yellow, frons black and prominent; occiput and rest of the head mat black; eyes dark brown, (Fig. 8). *Prothorax and thorax;* prothorax black on the dorsum and dirty yellow laterally; thorax (Fig. 9) black dorsum with fading colour towards the humeral region; the mid dorsal carina black; laterally a black stripe along the humeral suture broadening towards the dorsolateral side; mesepimeron and metaepimeron dirty yellow. *Legs:* coxae yellow, legs black with yellow flexor surfaces and claws bifid. *Wings:* (Figs. 12 & 13) Hayline, postnodal nervures 15 in forewing and 13 in hind; pterostigma mat black covering three cells; discoidal cells similar in both wings; Cu_{II} slightly arched at its origin; IR_{III} & R_{IV+V} arising much nearer arc than node; oblique vein present between R_{III} & IR_{III}; intercalated sectors present at apical ends; anal field small. *Abdomen:* black above getting dirty yellow downwards, deep black near the segmental joints. Anal appendages (Fig. 11) dark brown, tips black; inferiors yellow with black inner margines; superiors twice as long as the inferiors, forcipate, bending inwards to meet each other, spined along the outer border; furnished with a robust inner spine about two-thirds the distance from the last abdominal segment; inferiors rounded and club-shaped, less than half the length of the superiors. Genitalia as in Fig. 10.

Holotype 1 male in an envelope labelled "Manali, 6,000 ft., Pir Panjal Range, Himalayas; Coll. M.S. Mani & Santokh Singh, 25-v-1954; School of Entomology Expedition to the Himalayas 1954."

This species comes near to the *Lestes thoracica* Laidlaw in the Fraser's key[2] of the genus, but differs in the following: The length of the abdomen and wings; colour of labium, labrum not brown; no reddish brown humeral stripe and no metallic green stripe on the dorsum of the thorax; legs black with only flexor surfaces yellow; the position of the inner robust spine of the superior anal appendage; inferior appendages being rounded and club-shaped; in the number of the postnodal nervures in both the wings.

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[2] LAIDLAW. 1920. *Rec. Indian Mus.*, **19** : 152; FRASER, 1933. Fauna Brit. India, Odonata, **1** : 56.

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

PART VI.—TWO NEW SPECIES OF COLLEMBOLA

By H. N. BAIJAL, M. Sc., *Lecturer in Zoology and Entomology, School of Entomology, St. John's College, Agra.*

The two new species of Collembola were found by me in the material collected by the Entomological Expedition to Himalayas 1954 on glaciers and in streams just below them. Although Collembola were observed on snowfields in the Himalayas up to 14, 000 ft. by Parker[1], this is the first specific descriptions of such forms being published. Prof. M. S. Mani informs me that vast stretches of glaciers look sooty-black, owing to the gigantic swarms of *Podura himalayana*, sp. nov. settled on them. The type specimens are being deposited in the collections of the Zoological Survey of India, Calcutta.

I thank Prof. Dr. Mani for placing the Collembola collection at my disposal, for guidance and for facilities.

Suborder ARTHROPLEONA

Superfamily PODUROIDEA

Family Poduridae

Podura himalayana, sp. nov.

Body black. *Head* slightly longer than broad. Ocelli 8 on each side (fig. 3). Postantennal organ absent. *Antennae* short, slightly longer than head; first segment half the length of second, which is equal to third. *Trunk* entirely glabrous except the last abdominal segment which has some hairs. Mesothorax equal to metathorax. Fourth abdominal segment twice the third segment (fig. 1). *Legs* similar, short and stout; unguis slender, curved and acuminate; unguiculus (fig. 2) nearly one-third the unguis, unarmed; their distal portion abruptly narrowed becoming acicular. A single long stout tenent hair in relation to each foot. *Furcula* twice the antennae. Manubrium longer than dentes; mucro (fig. 4) straight, broad at base sharply acuminate at apex with a prominent upwardly directed terminal tooth and immediately behind it a second tooth. Mucro, dens and manubrium joints distinct.

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*Contribution No. 567 from the School of Entomology, published with the permission of the Professor of Zooloogy & Entomology.

[1] PARKER, R. N. 1921. *J. Bombay nat. Hist. Soc.*, **27** : 639.

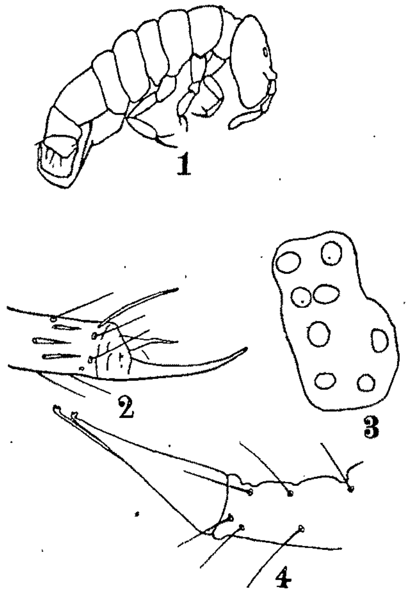

Fig. 1. *Podura himalayana*, sp. nov.
Fig. 2. Unguis and unguiculus of hind leg.
Fig. 3. Ocelli of one side.
Fig. 4. Mucro and apical portion of dentes.

Cotype partly dissected on slides, *paratypes* in spirit coll: M. S. Mani & Santokh Singh from glaciers and streams below glaciers 14000ft. Main Himalayas, Upper Chenab Valley, May-June 1954.

This species differs from the only other and cosmopolitan species *Podura aquatica* L.,[2] in body being glabrous; absence of postantennal organ, short antennae, mesothorax equal to metathorax, elongate and bidentate mucro and other characters.

Superfamily Mydonidae

Family MYDONIIDAE

Subfamily *Mydoninae*

Mydonius himalayensis, sp. nov.

Medium-sized, moderately pilose, live specimen gray. *Head* as long as broad, clothed with short hairs. Ocelli 8 (Fig. 6) on each side. Postantennal organ absent. *Antennae* twice the length of head with four segments; first

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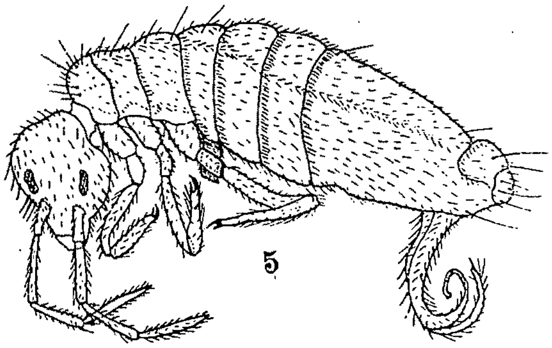
[2] LINNAEUS C. 1758. *Syst. Nat.* (10) : 608-609. SALMON. J. T. 1951. *Zool. Pub. Victoria Univ. College*, **8** : 7.

segment half the length of second, the second equal to third; the last segment a little longer than third. *Trunk* mesothorax very prominent with straight stout hairs on anterior margin; meso and metathorax almost equal in length. Entire trunk clothed with short hairs. Fourth abdominal segment (fig. 5) six times the third. *Legs* with unguis slender (fig. 8), strongly curved; acuminate and with two teeth; unguiculus a little more than half the length of the unguis; acuminate and margin without any teeth. No tenent hairs in their positions slender tapering setae. *Furcula* as long as abdomen, densely clothed with hairs; dentes a little longer than manubrium; mucro (fig. 7) small, with two equal-sized teeth, one behind the other.



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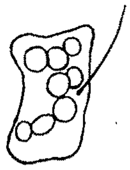

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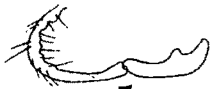

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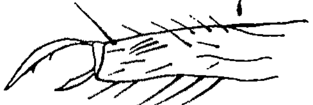

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Fig. 5. *Mydonius himalayansis* sp. nov.
Fig. 6. Ocelli of one side.
Fig. 7. Mucro and apical portion of dentes.
Fig. 8. Unguis, unguiculus and apex of tibiotarsus.

Cotypes partly dissected on slides, *paratypes* in spirit Coll. M. S. Mani & Santokh Singh on glaciers and streams below glaciers near Thirot 9500-11,000 ft. Main Himalayas, Upper Chenab Valley, 10. vi. 1954.

This species is distinguished from the other known Indian species *Mydonius crassa* (Imms)[3] in the different proportions of antennal segments, unguis without small tooth in middle of inner margin; absence of tenent hairs, bidentate mucro and in body colouration.

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[3] Imms, A. D. 1912. *Proc. Zool. Soc. London*, p. 96-97, pl. vii fig. 30-31 (*Entomobrya crassa*).

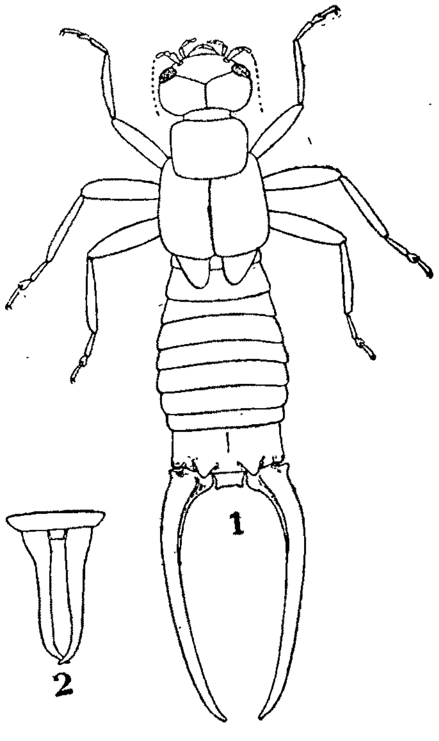
ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

PART VII.—ON A COLLECTION OF DERMAPTERA

By SANTOKH SINGH, M. Sc., *Research Associate, School of Entomology, St. John's College, Agra.*

The Dermaptera collected by the Entomological Expedition to Himalayas (1954) Upper Chenab Valley (Lahaul Valley) presents several interesting features. They represent material from the highest altitude at which earwigs have so far been observed in the world. The collection also contains apterous forms, which have not so far been recorded from our faunal region. Nearly one hundred specimens were collected near glaciers at night.

The type and other specimens are deposited in the collection of Zoological Survey of India, Calcutta. I thank Prof. M. S. Mani for guidance and facilities for work.



Anechura himalayana, sp. nov. fig. 1. male; fig. 2. forceps of female.

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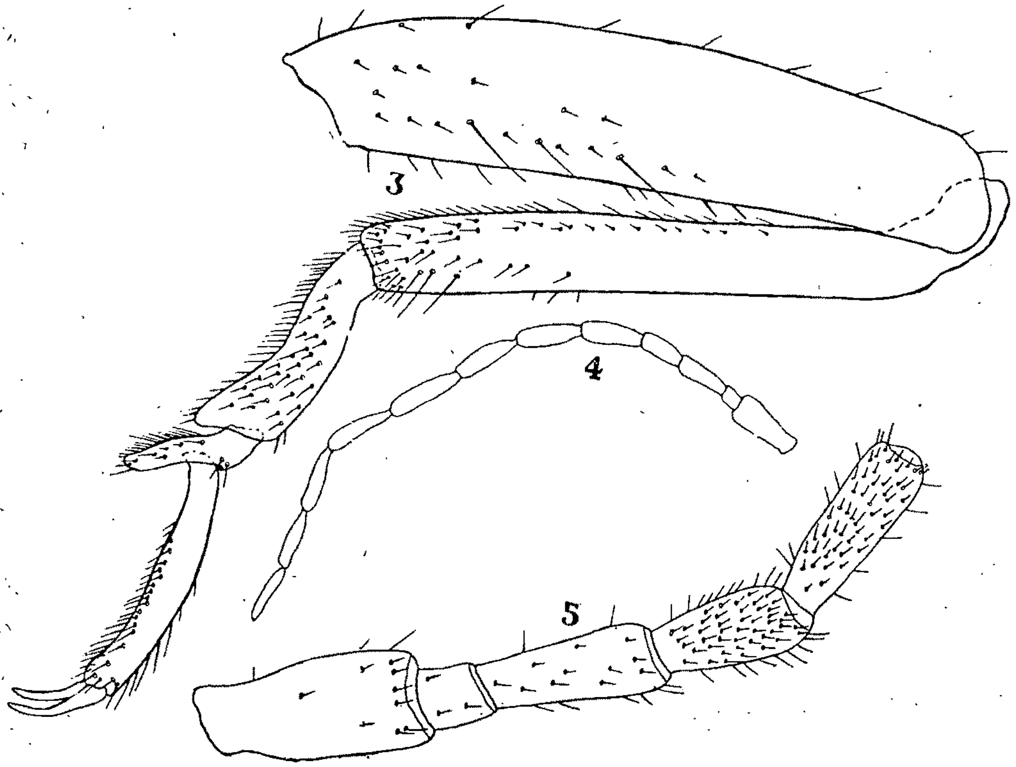
*Contribution No. 58 from the School of Entomology, published with the permission of the Professor of Zoology & Entomology.

Family FORFICULIDAE

Subfamily ANECHURINAE

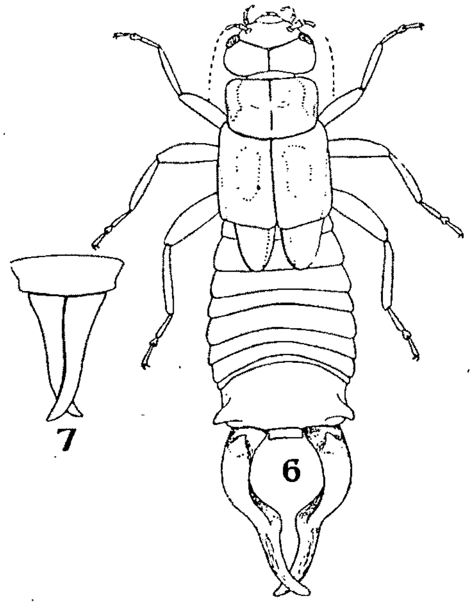
Anechura himalayana, sp. nov.

General colour black. *Antennae* with 12 segments (figs. 4 & 5), black, fifth segment slightly longer than third, remainder decidedly longer than third, eighth the longest and a little longer than the third segment. *Head* entirely black, shiny, sutures faint, frons tumid and truncate posteriorly. *Pronotum* completely black, transverse, about two and a half times as wide as long; *prozona* tumid with two small depressions one on either side of the suture; *metazona* flat; lateral sides rounded, median suture very faint. *Elytra* smooth, shiny black without keel. *Wings* well developed, conspicuously visible beyond the elytra when in repose. Sternal plates black, shiny; prosternum wide anteriorly and tumid, finely sculptured; meso and metasternum broad; only mesosternum rounded posteriorly while the metasternum is not so. *Legs* long and slender, entirely black; second tarsal segment broad and short; first segment slightly shorter than the second and third united (Fig. 3). *Abdomen* jet black, shiny, smooth, no bristles at the sides; tubercles of only the fourth segment distinct while the third poorly defined; broad and slightly broader about the middle;



Anechura himalayana, sp. nov. male; fig. 3. leg; fig. 4. antenna; fig. 5. first five segments of antenna.

narrowed posteriorly in female. Last dorsal segment of male not smooth, but obscurely sculptured, entirely black, transverse, depressed posteriorly, posterior margin not straight, normal basally without any inflation. On each side above the forceps there is a large mammiform, conical tubercle terminating in a sharp point; in the female last dorsal segment narrowed, depressed posteriorly and tubercles present. Penultimate ventral segment broadly rounded in both male and female. *Pygidium* in male prominent in the form of a broad transverse plate, with conspicuous tubercles postero-laterally; the posterior margin not reflexed and not crenulate; in female narrow and without postero-marginal tubercles. *Forceps* of male with the branches remote at the base, elongate and arcuate, with a strong sharp tooth on the upper surface near base; in the female branches not very remote (fig. 2), slender, straight, incurved at the apex; the inner margin depressed; forceps in both the sexes black. Forceps of variable size, ranging from a third to two-third of the body.



Anechura bipunctata pirpanjalae, var. nov. fig. 6. male; fig. 7. forceps of female.

	Length Male	Length Female
Body	9.5 to 15.5 mm	10.5 - 12.5 mm
Forceps	3.5 to 9.5 mm	3.0 - 4.5 mm

Holotype one male partly dissected on slide No. $\frac{\mathrm{I}\ (61)}{45}$ and on pin *Allotype* one femal on slide and pin No. $\frac{\mathrm{I}\ (61)}{7}$ labelled, School of Entomology Expedition to Himalayas 1954, Upper Chenab Valley (Lahaul Valley) 10,000-12,090ft. Coll : M. S. Mani & Santokh Singh. *Paratypes* 60 males and 73 females on pins and slides.

This species comes near *Anechura calciatii* Borelli [1] from which it can be readily disginguished by the absence of red colour on body, antennae with 12 segments, fifth longer than

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[1] *Burr*, M. 1910. Dermaptera (Earwigs). *Fauna Brit. India*, London p. 159.

third. Head entirely black; pronotum completely black; wings well developed and conspicuously visible behind the elytra; metasternum not rounded posteriorly; first tarsal segment shorter than the second and third combined; abdomen jet black, no bristles on the sides; last dorsal segment sculptured, entirely black; tubercles present in female on the last dorsal segment; sharp tooth on the upper surface of the forceps near the base.

Anechura bipunctata pirpanjalae, var. nov.

Antennae with 12 segments (Figs. 8 & 9). Head black, sutures distinct, clypeus straw yellow, labrum brown in female. *Pronotum* transverse with convex posterior margin, sides almost parallel, black with yellow sides, anterior margin light brown; *prozona* slightly tumid with two distinct impressions one on each side of the suture. *Elytra* short, shorter than posterior femora, dark brown, pale yellow outside the costal fold and marked fairly large pale yellow on the disc. *Wings* projecting beyond the elytra but not more than the length of the elytra, pale yellow with dark brown margin. *Legs* long and stout (fig. 10). *Abdomen* light brown with darker shading towards the base, last dorsal segment large, transverse and light brown throughout, at each exterior angle a strong conical tubercle pointing outwards, in between the tubercles another pair of mammiform rounded tubercle-like prominences; posterior margin depressed so as to cover the pygidium. In female last dorsal segment with exterior tubercles and finely sculptured; last ventral segment convex. *Pygidium* short and almost invisible by superficial examination, exterior angle bear a sharp pointed, conical black small tubercle. *Forceps* of male remote at base, stout, with a conical tooth near the base on the upper side; first they are directed outwards and upwards, then near the middle curved strongly downwards and inwards, last quarter of the length converge inwards to meet each other at the apex, hooked; reddish-brown; at the three-fourth length from where it starts converging a blunt tooth present. Forceps of female simple, arcuate, tender and forcipate (fig. 7).

	Length Male	Female
Body	11.5 - 12.5 mm	12.5 - 13.0 mm
Forceps	6.0 mm	3.5 mm

Holotype one male partly dissected on slide no. $\frac{1\ (28)}{1}$ and on pin, *Allotype* one female on pin no. $\frac{1\ (28)}{24}$. *Paratypes* one male and one female., labelled School of Entomology Expedition to Himalayas 1954; Khoksar, 12,000 ft. Upper Chenab Valley (Lahaul Valley); Coll: M. S. Mani & Santokh Singh 28.v.1954.

This variety comes near *Anechura bipunctata* (Fabricisus) var. *zubovskii* Semenov[2] from which it differs as follows:

Head black, clypeus straw yellow; anterior margin of pronotum light brown; last dorsal segment with a large conical tubercle pointing outwards; there is a second pair of mammiform tubercles inbetween the outer ones; posterior margin of the last dorsal segment depressed to cover the pygidium; exterior angle of pygidium bears sharp conical, black small tubercle.

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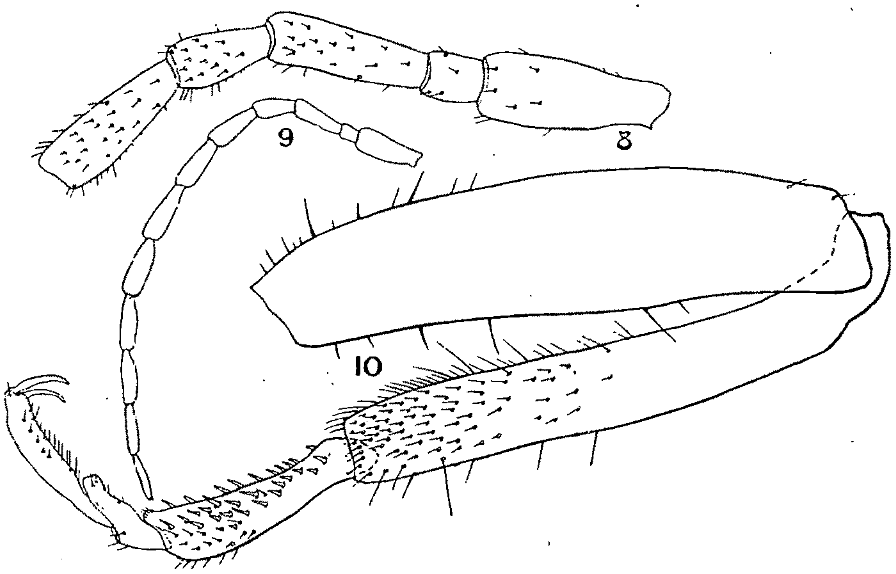
[2] SEMENOV, A. P. 1901. *Horae Soc. ent. Ross.*, St. Petersburg, **35** :188 (*Anechura zubovskii*)
BURR, M. 1910. *Faun. Brit. India*, Dermaptera (Earwigs) p. 160. (*Anechura zubovskii*)
BOESEMAN, M. 1954. *Zool. Verh. Rijksmus. nat. Hist.* Leiden, **21**:103 [*Anechura bipunctata* (Fabricius) var. *zubovskii*.]

Family FORFICULIDAE

Subfamily ANECHURINAE

Himanechura, gen. nov.

Antennae with 11 segments, the first robust, third cylindrical, shorter than the first but not robust, fourth shorter than the third while fifth longer than the third, the rest elongate and cylindrical. *Head* depressed and truncate posteriorly, sutures distinct. *Pronotum* distinctly wider than long; anterior margin punctate, posterior and lateral margins rounded. *Elytra* absent, meso- notum large but not differentiated into scutum and scutellum. *Wings* absent. *Legs* short and slender, second tarsal segment short and distinctly dilated. *Abdomen* depressed and dilated about the middle, narrowed towards the apex; last dorsal segment of male transverse, short; penultimate ventral segment of male gently rounded. *Pygidium* prominent and transverse. *Forceps* of the male slender and arcuate, branches remote at the base. Genotype.— *Himanechura lahaulensis*, sp. nov.



Anechura bipunctata (Fabricius), var. *pirpanjalae* nov. male fig. 8. first five segments of antenna; fig, 9. antenna; fig. 10. leg.

This genus comes near *Pterygida* Verhoeff 3, but differs in the absence of elytra and wings; antennae with 11 segments, fourth segment smaller than the third; pronotum wider than long. This is the first record of an apterous genus in the subfamily Anechurinae from India.

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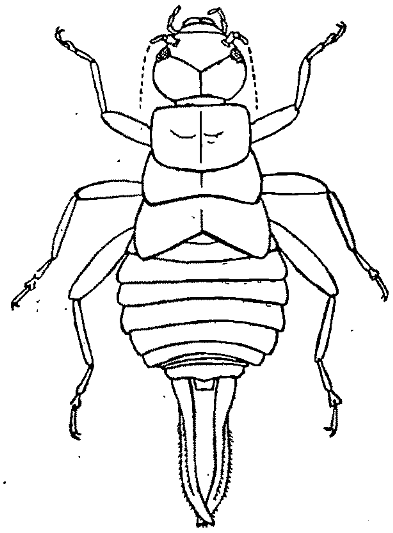
3 BURR, M. 1910. Dermaptera *Fauna Brit. India,* London, p. 157.

Himanechura lahaulensis, sp. nov.

Body strongly flattened and dilated, general colour black and shiny. *Antennae* with 11 segments (fig. 12), dark brown, third segment longer than fourth, but shorter than fifth (fig. 13), cylindrical with very minute constriction in the middle; remainder slightly longer than the third and cylindrical. *Head* depressed, smooth, shiny, black, sutures distinct, truncate behind; length one and one-fifth the width, interorbital space two-thirds the width of head. *Pronotum* transverse, one and a half times as wide as long, somewhat narrowed in front; very slightly narrower anteriorly than head; truncate in front, posterior margin slightly convex, lateral margins rounded, suture visible; *prozona* tumid; metazona rather flat; lateral sides smoky. *Mesonotum* transverse nearly three times as wide as long, posterior margin sinuate, suture distinct. Sternal plates transverse, dirty yellow. Femora brown (fig. 14), slender, as long as tibia; tibiae and tarsi slender, second tarsal segment short and dilated posteriorly (fig. 15); inner margin of tibiae and tarsi fringed with short bristles; femora with very few bristles. *Abdomen* flat and dilated near the middle, shiny, rugose, narrowing near the apex; last dorsal segment of male transverse, with indistinct tubercles at the postero-lateral corners; somewhat depressed in the middle; penultimate ventral segment of male gently rounded. *Pygidium* prominent, anterior margin broader than posterior; almost quadrate; postero-lateral corner produced into short obtuse knob like processes; as long as the last dorsal segment. *Forceps* of male slender and arcuate, branches remote at the base, unarmed, triquetral in transverse section; provided with a row of minute bristles along the dorsal and outer margin



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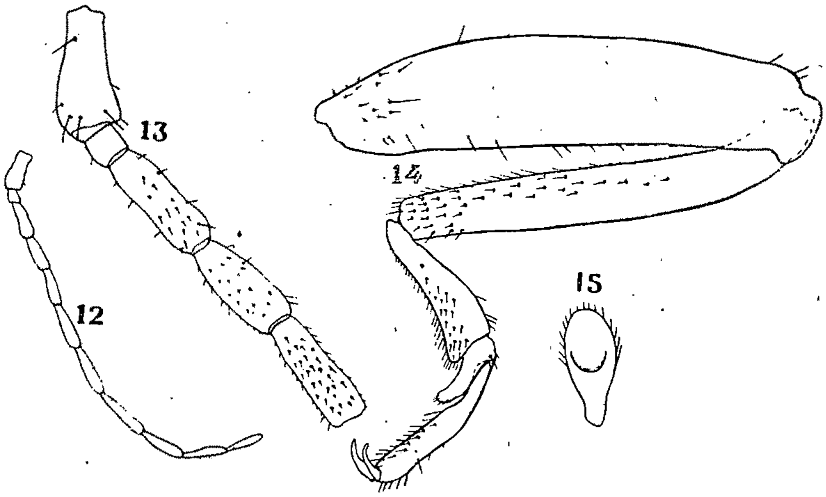
Himanechura lahaulensis, sp. nov. male.

of the triangle; a small tooth present on the outer margin near the base; nine times as long as thick at the base; enclosing a regular oval area; one half as long as the body.



Himanechura lahaulensis, sp. nov. male; fig. 12. antenna; fig. 13. first five segments of the antenna; fig. 14. leg; fig. 15. second tarsal segment.

Holotype one male on pin and slide No. $\frac{1\ (28)}{17}$; *Paratypes* 13 males on pins and slides, labelled School of Entomology Expedition to Himalayas 1954; Khoksar, 12,000 ft. Upper Chenab Valley (Lahaul valley) Coll. M. S. Mani & Santokh Singh, 28. v. 1954.

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS

VIII.—Notes on Plant Galls From The Himalayas*

By M. S. Mani, M. A., D. Sc. F. R. F. S., F. L. S., *Professor of Zoology and Entomlogoy, St. John's College Agra, India.*

Introduction

This paper deals with a brief account of the biology and ecology of plant galls from the Himalayas. Stretching east-west nearly 2600 kilometres, a narrow wall of high mountains, rising somewhat abruptly from the plains of India (Fig. 1) with variations in altitudes from 1500 ft. to over 20,000 ft., the Himalayas possess a remarkable range of climate and vegetation, perhaps unparalled anywhere in the world. Here we have transition from the tropical, subtropical and warm, through temperate and alpine to truly arctic conditions. The outer Himalayas or the foot-hills of the Himalayas comprise a series of ranges between 6000 ft and 8000 ft. North of them lie the inner Himalayas, rising to about 15000 ft and further north is a narrow belt, hardly wider than 40 kilometres (north-south), comprising the main Himalayan peaks, rising to 23 000—25,000 ft. The Sub-Himalayan belt includes in the north-west the Siwaliks also and in the east we may likewise include Khasi hills within this floral and faunal belt. The outer and inner Himalayas are intersected by numerous water courses, with the hills presenting mostly the southern aspect. While the peaks generally rise up to 20,000 ft or more, the ravines are remarkably low (the bed of the river Ganges for example near the Gangotri glacier is only 8000 ft), often as low as 2000 ft. The Sub-Himalayan floral and faunal elements frequently penetrate deep into the inner Himalayas through these ravines. The main Himalayas, with scanty vegetation even within the limits of tree growth and in the valleys, constitute a region of arid cold conditions.

While we have numerous excellent accounts of the geography, geology, distribution and ecology of vegetation of the Himalayas (5, 14, 32, 33, 34), our knowledge of the plant galls occurring in this remarkable area is extremely fragmentary. The study of galls seems to have been sadly neglected in India as a whole and we hardly know 600 galls in such a vast country with an extremely varied flora. Buckton (2), Cameron (6) and Kieffer (20, 21) were perhaps the only early workers to give us an account of about a dozen galls from the Himalayas.

Recently I made several trips to the Himalayas and made extensive collections of galls, gall insects and other organisms associated with them. The

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*Contribution No. 50 from the School of Entomology; cecidological contribution No. 24. Based on a paper read at the Eighth International Botanical Congress at Paris, July 1954.

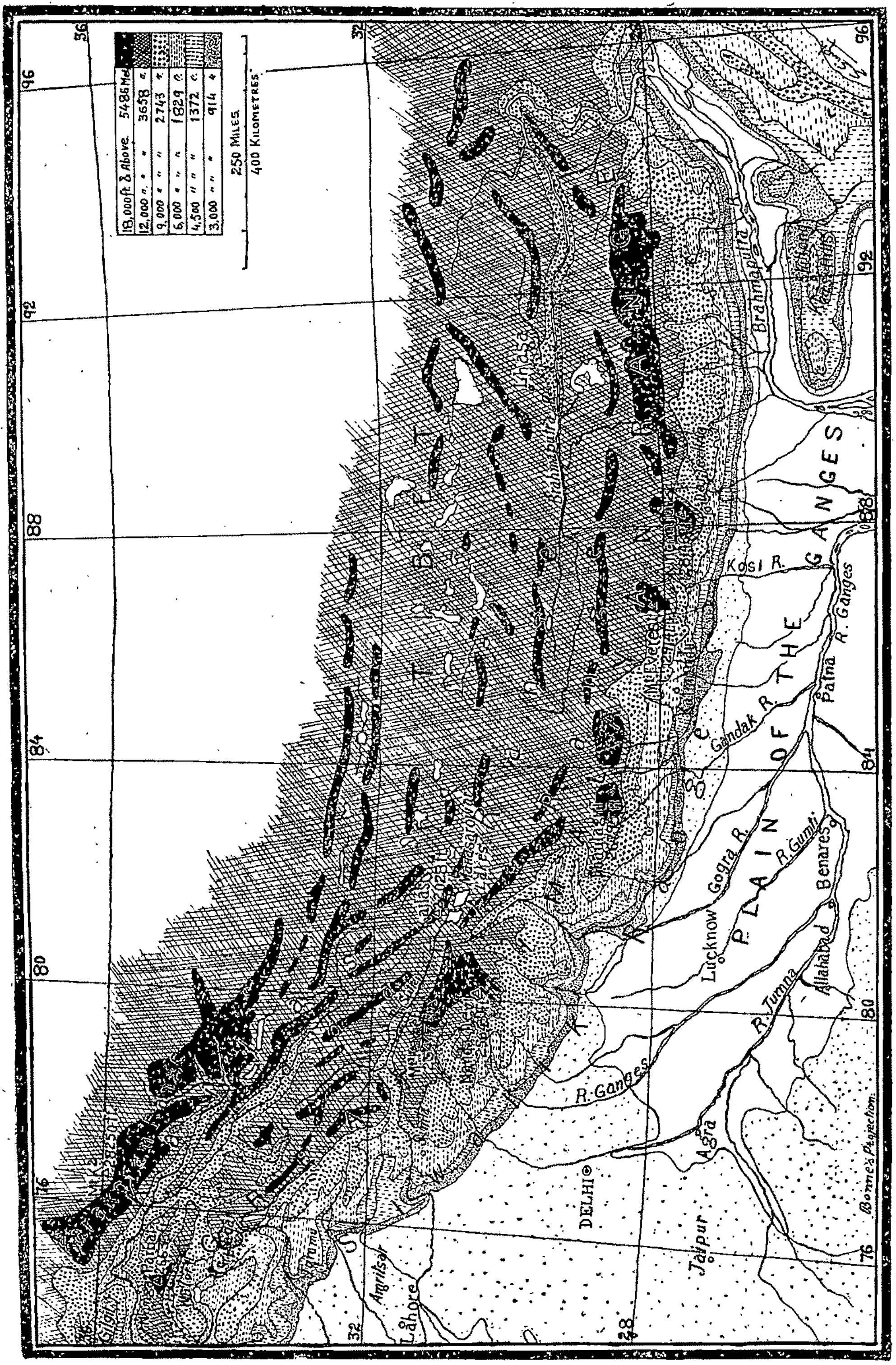

Fig. 1 A sketch map of the Himalayas.

areas thus surveyed include the Kumaon, Garhwal, western and north-western Himalayas (Fig. 1). I have also a few undescribed galls on unknown plants from the Nepal-Terai Himalayas. A great part of these collections has already been described by me in a series of papers (27, 28, 29, 30). In the course of these surveys, in addition to making collections of galls, observations on the biology and ecology of the various galls were also made wherever possible. The galls so far collected and studied by me or recorded by earlier workers constitute about one-fifth of the total number of galls known from India as a whole. This doubtless represents an exceedingly small fraction of the total gall wealth of the Himalayas. The material so far collected, though fragmentary, presents certain extremely interesting features and should stimulate further research.*

The variety and abundance of galls fall off rapidly beyond the tree growth limits, which vary between 10,000 ft and 12,000 ft (Fig. 2), but the higher regions are by no means wholly barren and several remarkable galls have been collected just by the sides of some of the permanent glaciers at about 15,000 ft. The Sub-Himalayan and outer Himalayan belts and the ravines of the inner Himalayas are as a whole richer in galls than the main Himalayas. Galls are also relatively more abundant on the southern aspects of the ranges and likewise on steeper rather than on the more gentle slopes at the same elevations and aspects.

Several of the galls in the Sub-Himalayan and outer Himalayan floral belts have two generations from spring to autumn. The galls from the temperate Himalayas as a rule have but a single generation. They are also mostly hard, woody galls, with tough resistant bark and persisting on branches or often remain buried under snow during the winter. The gall insects, well protected within the larval cavities of the nearly dry galls, hibernate the whole of the winter under several feet of snow. With the spring thaw, water soaks through and penetrates the gall cavities. This wetting breaks the hibernation and leads to the completion of metamorphosis and emergence of adults in April. This event also coincides with fresh growth of buds and twigs and sprouting of new leaves and a new generation of galls results. The growth of the galls is rather rapid and the entire phase of the cycle is completed within the short summer. At lower altitudes the emergence of gall insects occurs twice: first with the onset of spring and again with the first rains of the monsoon.

About half the total number of galls so far known from the whole of the Himalayas (Fig. 4) develop on plants belonging to Lauraceae, Compositae, Leguminosae, Rosaceae and Fagaceae. While galls on Compositae are practically unknown in the plains of India, they seem to be not only widely distributed but even abundant in the Himalayas. They ascend slightly above the limits of tree growth (Fig. 2) and are often found exclusively at fairly high altitudes (14,000 ft.) on sides of glaciers. This is specially true of the Compositae galls produced by Itonididae (Diptera). Galls on Leguminosae are particularly abundant between 6000 ft and 8000 ft. Rosaceae galls occur only in isolated

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*The galls collected by the Expedition to upper Chenab Valley (1955 *Agra Univ. J. Reg.*, 4 : 157) are not considered in this paper.

patches, often never below 9000 ft. While a number of species of oaks are common in the Himalayas and ascend up to the tree growth limits (e.g. *Quercus semicarpifolia*), an extremely small number of galls is so far known in the Natural Order Fagaceae.

Nearly 60% of the known galls are on leaves (Fig. 3), about 25% of them develop on branches, 15% on buds and other parts of plants. More than one-third of the leaf galls are produced by Itonididae, one-fourth by Eriophyidae (Acarina) and the rest largely by Psyllidae (Homoptera). Two-thirds of the branch and bud galls are accounted for by the family Itonididae. Of the total number of galls by Itonididae, nearly 80% are produced on leaves and the rest on branches, buds and flowers. Most of the Eriophyid galls are on leaves. These are usually confined to the lower altitudes and are remarkably abundant on southern aspects and on wind-ward sides of the hills. The midge galls (Itonidid galls) occur equally in the Sub-Himalayan and inner Himalayan zones. The Cynipid and aphid galls, on the other hand, appear to be peculiar to the temperate Himalayas. Most of the galls occurring in the Himalayas are peculiar to that region, but some like gall No. 55 on leaf of *Garuga pinnata* Roxb. caused by the psyllid *Phacopteron lentiginosum* Buckton, are found throughout India and in the Sub-Himalayan and outer Himalayan belts. Some examples of galls are also known to occur in Europe, being widely distributed in the Himalayas.

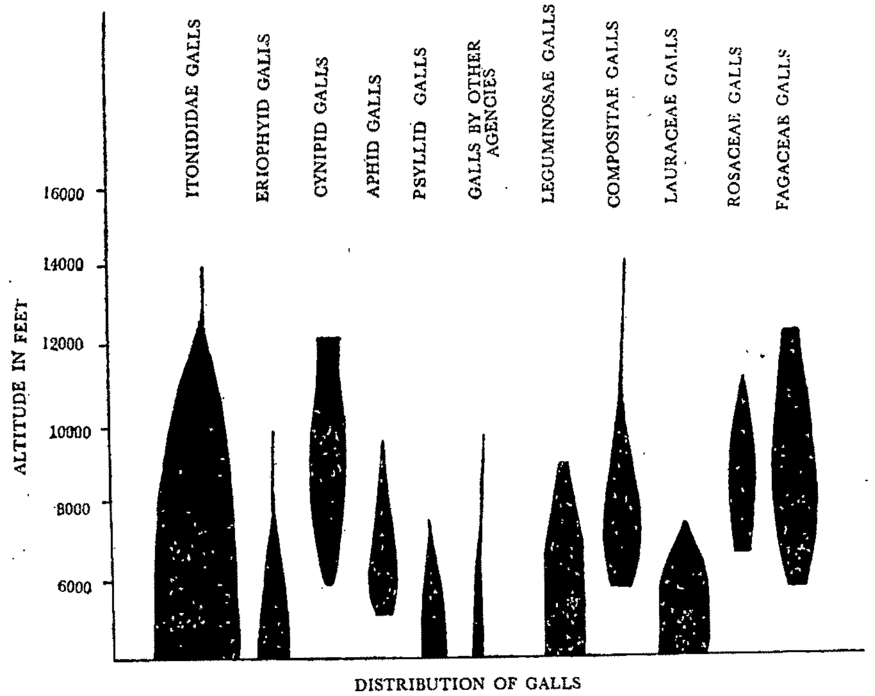

FIG. 2. Distribution and abundance of different galls at different altitudes in the Himalayas.

This for example is the case with gall Nos. 505 and 527 on *Achillea mellifolium* by *Rhopalomyia* spp. and gall No. 428 on *Rhododendron arboreum* by the fungus *Exobasidium.*

CAPPARIDACEAE

The Natural Order Capparidaceae is well represented in the Himalayas, especially in the foot-hills. While a number of galls are known from the plains, we have so far only a single gall from the Himalayas. The midge *Oligotrophus indicus* Kieff. (21: 152; 19: 295, No. 1067) gives rise to irregular multilocular tumescence of branches, petioles and midrib of leaves (Gall No. 170, Mani, 27: 132) in the eastern Himalayas. Kieffer records that the midges emerge in January from undergound pupae; these records are perhaps based on some error. It is not usual for gall insects to complete metamorphosis in January in the Himalayas. It is also usual for midges to pupate in branch and petiole galls.

TERNSTROEMIACEAE

Altogether seven galls are known, four of which are on leaf and one each on bud, branch and root. Itonididae are responsible for four galls. The other galls are caused by thrips, coccids and eelworms. The midge *Lasioptera longispatha* Kieff. (21: 157; 19: 557, No. 2023), described only from the larvae, causes multilocular, globose, solid fleshy bud galls (Gall No. 176, Mani, 27: 133) on *Camellia drupifera* Lour. in the eastern Himalayas. Another midge *Schizomyia incerta* Kieff. (21: 153), also described from larvae only, produce on leaf of *Eurya japonica* Thunb. subglobose, fleshy and unilocular galls (No. 177, Mani, 27: 134) in the eastern Himalayas. The larvae enter the soil for pupation, a habit unknown in the species of *Schizomyia.* On the same plant Kieffer (21:154) has also recorded a subglobose, bilocular densely pubescent hypophyllous gall by an unknown midge (Mani, 27: 134, No. 177a). There are two galls on *Schima wallichii* Choisy. *Lasioptera trilobata* Kieff. (21: 157-158), also known only as larvae, is associated with globose, fleshy, unilocular, solid galls, visible equally on both sides of the leaf in the eastern Himalayas (Gall No. 178, Mani, 27: 134). The gall cavity is surrounded by hard tissue and contains a single yellowish larva. The psyllid *Cecidopsylla schimae* Kieff. (20:165; 19: 558, No. 2025; 27: 110, No. 51) gives rise to hollow, fleshy leaf-margin-roll gall in Kurseong. This is perhaps one of the very few leaf-margin galls so far collected in the Himalayas. The emergence of the adults occurs in July. Root galls (No. 124, Mani, 27: 95) on *Thea sinensis* Linn. from the eastern Himalayas are caused by the eelworm *Heterodera marioni* at low altitudes (13). According to Green and Mann (17), irregular, extensive and solid tumescence of the branches of *T. sinensis* are caused by the coccid *Chionaspis manni* Green at Darjiling and other parts of the eastern Himalayas. This is the only example of a gall by coccids from the Himalayas.

BERBRIDACEAE

Three galls are so far known. An unknown Trypetid fly (Diptera) gives rise to fleshy, solid, multilocular agglomerate galls on buds of *Berberis lycium* in the central and western Himalayas (29: 136, pl. i, fig. 7, No. 420). This is perhaps one of the two galls caused by Trypetidae from India, both of which are in the Himalayas. This family is usually associated with galls on Compositae in Europe, but so far this association has not been observed in the Himalayas. During autumn the galls contain mostly the puparia of the fly. Prof. Elmo Hardy, the well known authority on these insects from Hawaii, infoms me that a fruitfly very close to the genus *Rhagoletis* is associated with this plant in the Himalayas, but at lower elevations of about 4000 ft. and it is not known whether this species that normally breeds in fruits of *Berberis*, also attacks the buds and causes gall formation at somewhat higher altitudes. The bud is considerably swollen and is clothed with numerous scaly imbricating apices of the vestiges of leaves. Although this species of barberry is extremely common in the whole of the sub-Himalayan, outer and inner Himalayan belts throughout the central and western Himalayas and ascends almost up to 10,000 ft. in the outer Himalayan belt, this gall is extremely limited in its distribution. A second gall (No. 425) was recently described by me (29: 137, pl. i; 30: 26) on the branches of the same plant caused by an unidentified fungus. This is a hard, woody, unilateral cortical outgrowth, composed of parenchyma cells, with radial groups of wood. The fungal perithecia are distributed beneath the epidermis. The gall was originally collected in autumn in the central Himalayas at altitudes ranging from 6000 ft to 7000 ft. During summer of 1953 the gall was found in exceedingly great abundance in the western Himalayas, especially in the Dholadhar and Pirpanjal

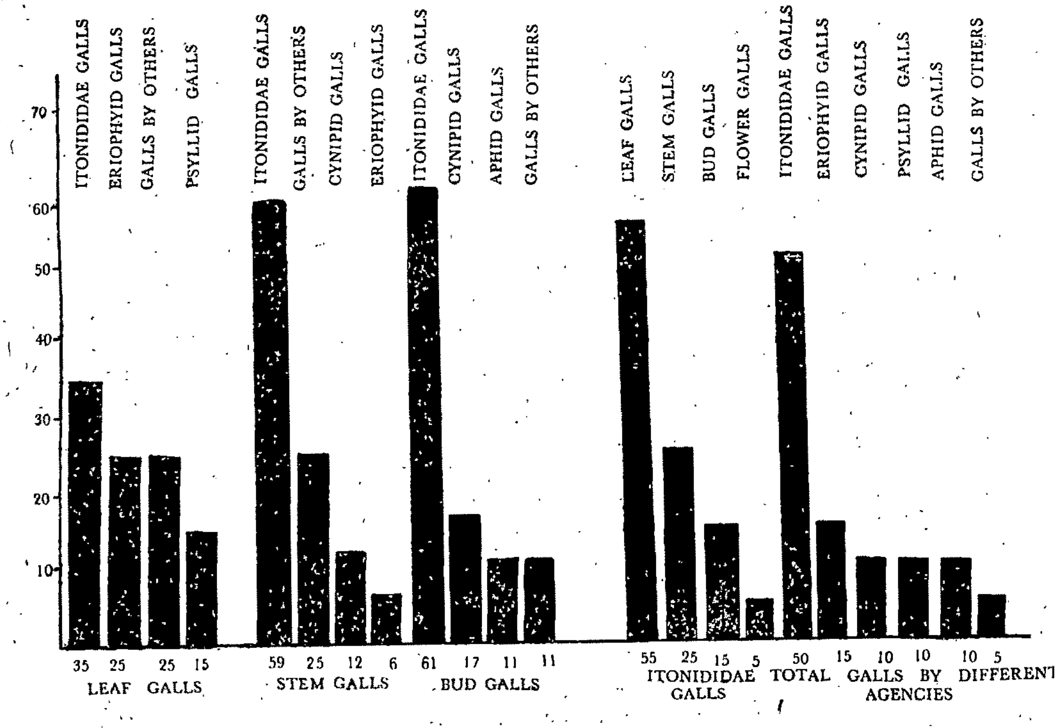

FIG. 3. Relative abundance of different galls in the Himalayas.
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ranges, nearly up to 9000 ft. Some of the examples in that area appear to attain relatively large proportions, often exceeding a diameter of 50 mm. The average size in the foot-hills usually never exceeds a diameter of 25 mm. On *Holboellia latifolia* Wall. we have an interesting irregular tubercular outgrowth of the branches (Gall No. 423, Mani, 29: 137,) caused by an unknown midge in the central Himalayas. The galls forms a continuous growth extending to over 100 mm of the branches, with numerous larval cavities. The entire gall is formed from the sub pidermal cells of the cortex. The pressure of the ce proliferation from this region causes irregular bursting of the epidermis.

BURSERACEAE

An extremely interesting gall (No. 55) is produced by a large and conspicuously spotted psyllid *Phacopteron lentiginosum* Buckton (4; 25: 102; 29: 75) on leaves of *Garuga pinnata* Roxb. The galls are subglobose or oval, hard, hollow, yellow or reddish-brown growths from a conspicuous cup-like swelling of the leaf. Each gall measures about 20 mm long and 10 mm in diameter. The spacious gall cavity contains one or two nymphs of the psyllid or its parasites. The mature galls burst irregularly above and thus permit the escape of the last instar nymph, which crawls out on the leaf and undergoes the final moult into the adult. This gall is one of the commonest in the central Himalayas, in the whole of the Kumaon and Garhwal areas. It is also abundant and widely distributed throughout India, on hills and plains. On the Himalayas the galls do not however occur above 6000 ft. It is also interesting to note that occurrence on the foot-hills seems to be restricted to the southern aspects, and particularly to the river valleys.

RHAMNACEAE

Beutelgalls about 1 mm high and visible on both sides of the leaf blade (Gall No. 437) and tubercular fleshy multilocular emergences about 4 mm in diameter from the sub-epidermal layers of cortex of branches of *Rhamnus virgata* are produced by *Eriophyes* sp. in several localities, varying in altitude from 5000 ft to nearly 7000 ft. on southern aspects of the Sub-Himalayan and outer Himalayan belts. The cavity of gall No. 436 is filled with complicated fleshy outgrowths bearing simple trichomes. An apical ostiole permits emergence of mites (Mani, 29: 138-139 Diffuse solid tumescence of branches or also leaf blades (Gall No. 419) are produced by an ascomycetous fungus at 6700 ft. in the western Himalayas (30:27). This gall seems to be confined to the moist white-oak (*Quercus incana*) forests An interesting rosette-gall (No. 441) on the terminal buds of *Sageretia oppositifolia* Brongn. (29 : 139), with the larvae of an unknown midge in small pyriform, fleshy chambers at the bases of the greatly crumpled and irregularly lobed leafy outgrowths, was recently collected by me in the central Himalayas at about 7000 ft in the white oak forests. All the galls so far collected on Rhamnaceae from the Himalayas seem to be restricted in their distribution to the *Quercus incana—Rhododendron arboreum* formation and seem to finish in the southern ranges of the outer Himalayas.

VITACEAE

We have so far single gall. Irregular, hard, solid swellings of branches, tendrils, petioles or entire buds of *Vitis semicrodata* Wall. (29 : 139, pl. i, fig. 4; 30: 28), produced by an unknown midge (Gall No. 432) throughout the central, western and north-western Himalayas, at altitudes varying from 6000 ft. to nearly 9000 ft. The gall formation begins in early summer and the galls persist on the plant during the winter snowfall. This gall is also confined to the *Quercus incana* forests. The maximum size of the gall is reached in autumn and may frequently reach 30 mm in diameter and represent agglomerate Hard masses.

SAPINDACEAE

Gall No. 506 is an epiphyllous, yellowish beutelgall on the Himalayan horse-chestnut *Aesculus indica* Colebr., produced by *Eriophyes* sp. during summer at about 8000 ft in the western Himalayas and penetrating nearly to the inner Himalayan belt (30 : 28).

SABIACEAE

Two extremely interesting midge galls have been found in the outer Himalayan ranges of the western Himalayas. Gall No. 485 (Mani, 30: 28) is produced by an unknown midge on midrib and some of the larger veins of the leaf of *Meliosma rigida* S. Z. at 7000 ft. The gall comprises diffuse unilateral swellings from cortex, with numerous irregular larval cavities. This gall is confined to open and thinned out areas of *Quercus incana* forests and does not persist on the plants.

At somewhat higher elevations (about 9000 ft) in the Dholardhar and Pirpanjal ranges the newly described gall midge *Acroectasis campanulata* Mani.

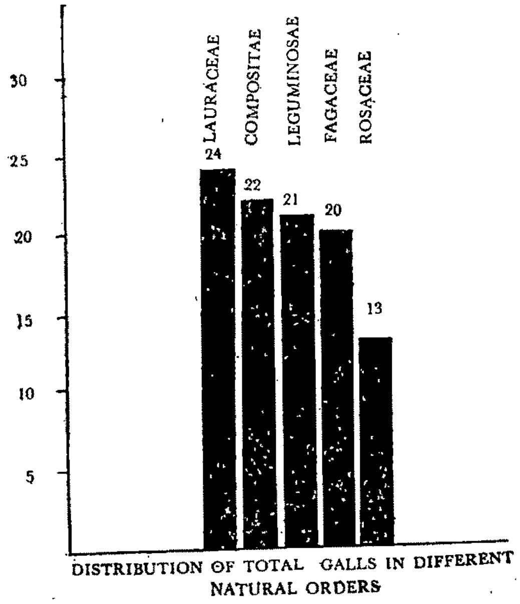

FIG. 4. Percentage of galls on plants of certain Natural Orders in the Himalayas.

(30 : 17) produces an astonishingly great abundance of fleshy, smooth, solid, unilocular, pepper-shaped galls from the epidermis and subepidermal cells on the branches of *Sabia campanulata* Wall. (Mani, 30 : 29, gall No. 500, pl. vii). *S. campanulata* is a deciduous climber, with stems up to 25 ft long and often an inch thick, mostly green and smooth. The galls develop all round the stem, close to each other, but generally never agglomerate, continuously for several feet of the branch, often extending to over 6 ft, giving the entire branch a curious pepper-spike-like appearance. The adult midges emerge in exceedingly large numbers throughout the day and night during June. This is perhaps one of the few galls which go through two rapid generations during the summer in the Himalayas at this elevation. This is also one of the very few galls in which the incidence of Hymenopterous parasites of the midge is either exceedingly low or totally absent.

ANACARDIACEAE

A pine-cone-like terminal bud gall (No. 57), with thick imbricating scales and measuring up to 20 mm in diameter, produced by *Psylla cistella* (Buckt.), on *Mangifera indica* Linn. is extremely common in the foot-hills and reaches up to 6000 ft. This gall also occurs in certain parts of the plains (29 : 73). The psyllids occur in large numbers in the spaces between the bases of the imbricating scales. We have another curious-looking reddish-brown echinate gall (No. 196) on leaf of *Mangifera indica* Linn. caused by the midge *Amradiplosis echinogalliperda* Mani (26: 443; 28: 49) in the Sub-Himalayan belt, in valleyes between the Siwaliks and the edge of the outer Himalayas. A single leaf may bear as many as 50 galls. There are two generations, which generally overlap: March-April and September-October generations. Gall No. 198 on leaf veins of *Odina wodier* Roxb. by *Odinadiplosis odinae* Mani (24: 435-439; 26 : 441; 29 : 140), known to occur throughout India, has also been collected at several localities on the foot-hills up to about 7000 ft, on southern aspects of the hills, both in the Kumaon and north-western Himalayas. This gall belongs to the tropical Himalayas. One of the best known galls in the Sub-Himalayan and outer Himalayan belts of the north-west is gall No. 105 on *Pistacia integrimma* Stew. by the aphid *Dasia* (*Pemphigus*, partim) *aedificator* (Buckt.) (2: 71; 12 : 144; 40 : 16; 27 : 83, 121). The elongate, horn-shaped, legume-pod-like gall, often gorgeously pinkish tinted, and attaining to over 300 mm long, turn brown when old, but persist for one or two years on the plant. The old galls are usually inhabited by several species of spiders, ants and Coccinellids, especially *Coccinella septempunctata* Linn. This gall is also known to occur in Baluchistan and Afghanistan and has been used in ancient Hindu medicine. There is another leaf gall (No. 106) on *P. klinjuk* St. by an aphid from the same area (27:122). The recently described gall No. 447 on leaf of *Rhus javanica* Linn by *Eriophyes* sp. occurs in large numbers in *Quercus incana* forests at about 7000 ft in the Kumaon Himalayas during the monsoon rains (29 : 160).

LEGUMINOSAE

A number of galls are known. The Leguminosae galls represent almost 21% of the total galls occurring in the Himalayas (Fig. 4). We come across more of these galls in the Sub-Himalayan and outer Himalayan belts than in the inner Himalayas. Some of the plants occur at fairly high elevations (13 000 ft or slightly more as in case of *Caragana*) in the inner Himalayan ranges and in such cases the galls seem to be produced on flowers during the short summer. Most of Leguminosae galls are caused by midges. Only two galls are produced by mites and these are confined wholly to the foot-hills. In the western Himalayas at about 7000 ft an unknown weevil gives rise to fusiform branch galls on a species of *Desmodium* (Gall No. 488, Mani, 30 : 29). Five galls are known on *Indigofera dosua* Ham. from the central and western Himalayas. Gall No. 429 (29 : 141) by an unknown midge on leaves is an extremely common gall in *Quercus incana* forests, especially on southern aspects of the hills, at altitudes ranging from 4000 ft to nearly 8000 ft. During May and June the gall contains a single larva. There is undoubtedly a single generation of this gall. Gall No. 430 is also produced by an unknown midge in the central Himalayas, especially the Garhwal and Kumaon regions at elevations upto 8500 ft (29 : 142, pl. ii, fig.1). This is an irregular, solid, hard swelling of buds and branches with numerous larval cavities. It is moderately abundant in the Kulu valley, Kangra and other parts of the Himachal region of the north-western Himalayas. From these areas a fairly common globose, hollow, unilocular gall on branches is produced by the recently described midge *Oxasphondylia dosua* Mani (30 : 22, 30) (Gall No. 483). This gall is similar to gall No. 429 on the same plant and likewise extends between 6000 ft and 9000 ft. A fourth gall by midge (No. 484) on *I. dosua* from the same area but rather found at lower elevations (6000 ft.), presents certain interesting features (30: 30, pl. vii). Numerous small oval or subglobose, hollow, unilocular galls develop wholly concealed beneath the bark, so that the branch becomes conspicuously swollen locally into a fusiform mass, with irregular projections on the surface, indicating each of the galls beneath. As the galls below the bark mature, the bark itself cracks off in irregular patches and exposes the numerous nodular galls within. This also permits the escape of the adult midges through the exit holes, which were so far covered up by the bark. The old dry galls persist for several months on the branches after the covering of bark has fallen off. An undescribed species of *Eriophyes* produces gall No. 431 on leaflets of *I. dosua* in great abundance in the Kumaon and Garhwal regions, where this gall ascends upto about 8000 ft on the southern aspects of the hills (29: 140). This gall seems to be closely associated with blanks in *Quercus incana* forests, but it also occurs in open *Pinus longifolia* regions at 7000 ft. The gall becomes relatively scanty below 5000 ft and is rather sparse in dense undergrowths concealed by grass.

In the western and north-western Himalayas, *Indigofera gerardiana* Wall. a medium-sized deciduous shrub, with pretty pink and rosy flowers, has five interesting galls, some of which appear to be counterparts of the galls on *Indigofera* *dosua*. Most of the galls on *I. geradiana* are however met with in particular abundance between 8000 ft and 10,000 ft, and occasionally in blue pine and spruce forests during summer. Perhaps the most interesting of these galls is gall No. 486 on bud, a large, extremely conspicuous, cottony-white to bluish-white, fleshy, hollow, unilocular structure covered by dense, fleshy, cylindrical, slender, pubescent, elongate outgrowths, producing a curious bedegaur-like appearance. A single gall often measures about 20 mm in diameter and a twig frequently bears over 70 galls. From this gall was recently reared a large-sized midge *Oxasphondylia echinata* Mani (30: 20, 31, pl. vii). The adult midges emerge in fairly large numbers during May and June and seem to give rise to a second generation (?). The gall is most abundant between 8000 ft and 9500 ft and rather scarce below 7000 ft. The incidence of parasitism by Chalcidoidea is relatively low during June (early part). The inflorescence axis of the same plant is turned into an elongate-fusiform, hollow utricular and echinate gall (No. 487) by another midge at 6000 ft and 8000 ft in the western Himalayas (30: 31, 32, pl. vii). During June a fleshy solid, subglobose or cordate flower gall (No. 490) is produced by *Oxasphondylia floricola* Mani (30: 25, 32, pl. vii) on *Indigofera gerardiana* at elevations between 7000 ft and 8000 ft in the western area. Gall No. 503 by an unknown midge is similar to gall No. 429, but somewhat larger and more deeply pinkish-coloured and with rather smooth surface, to be met with in late June at 7500 ft. This gall appears only after the first rains. Gall No. 494 by *Eriophyes* sp. on leaflets of *I. gerardiana* is similar to No. 431 on *I. dosua* but relatively sparse.

The most remarkable gall is No. 457 by an unknown midge on branches of *Indigofera pulchella* Roxb. (29: 142, pl. i). As in case of gall No. 457 on *I. dosua*, a series of small, globose, fleshy, unilocular, closely crowded galls develop wholly under the epidermis, each gall containing one or two larvae of the gall midge. With the maturing of the galls a localised diffuse swelling of the branch and pressure of growth from within result in rupture of the bark, which falls off completely and reveals dense, fine, silky, deep reddish or reddish-brown eruption of soft erineal globose masses, enclosing the individual galls within and projecting conspicuously on the surface of the branches. These growth cover often extensive lengths of the branches, upto over 50 mm lengths. This gall is abundant in early summer in the Garhwal Himalayas, especially between 7000 ft and 8000 ft.

Gall No. 513 is an irregular, solid, green, terminal or axillary bud gall, often 30 mm in diameter, with numerous small larval cavities, produced by an unknown midge on *I. pulchella* at 7000 ft in the Garhwal Himalayas during autumn, especially in the outer floral belt. Gall No. 517 on the same plant is very similar to gall No. 430 on *I. dosua* and is caused by an unknown midge in Garhwal.

ROSACEAE

Rosaceae are widely distributed on the Himalayas and frequently ascend to about 13,000 ft. The total number galls which has so far been collected is however extremely small. Most Rosaceae galls appear to have extremely localised distributions. Out of the eight galls so far recorded, four are on leaf, three on branch and one on root. Aphids account for four galls, Itonididae for two, Cynipidae two and Coleoptera one. Intensive collections will undoubtedly reveal many more cynipid galls, especially on roses. We have at present only two galls on roses, both from the extreme north-west of the Dholadhar and Pirpanjal ranges. Gall No. 497 is a cynipid gall on the branches of *Rosa macrophylla* Lindl. Each gall represents probably a transformed terminal bud. It is globose, solid, hard, woody, multilocular swelling, moderately densely clothed with fleshy spines and leafy vestiges, green to deep pinkish and measuring about 30 mm in diameter. A number of this gall was collected at elevations of about 8000 ft in the western Himalayas and between 6500 ft and 9000 ft on the Pirpanjal ranges from late spring to early autumn (30:33, pl. viii). The old galls persist on the branches as dry brown masses. Some of the galls thus persisting on the branches were dug out of fresh snow and on examination were found to contain the pupae of the cynipid inside the larval cavities. This gall is very similar to the gall on *Rosa sicula* Tratt. by *Rhodites mayri* Schl. from Algeria (19: 320, No. 1164, fig. 665-667). *Rosa* galls are confined to the outer and inner Himalayan ranges only. On the under side of the leaves of *Rosa macrophylla* in the southern spurs of the Pirpanjal ranges at about 8000 ft we meet with gall No. 499 by another cynipid. This is a smooth, globose, fleshy, unilocular, sessile, yellowish gall, about 5 mm in diameter (30: 33, pl. viii).

Though several species of brambles occur throughout entire length of the Himalayas, we know only a single midge gall from the eastern Himalayas. Gall No. 214 on *Rubus assamensis* Focke from the Sub-Himalayan belt in the east is an echinate gall on leaves, caused by the midge *Schizomyia assamensis* Felt (15: 3; 40: 37; 19: 316, No. 1144; 23:406; 27:140).

The root nodosities on *Pirus malus* by *Eriosoma lanigerum* (Hausm.) are met with in several parts of the extreme north-west Himalayan valleys (27). The weevil *Alcides mali* Marshall produces diffuse fusiform branch galls (No.130) on *P. malus* in the Sub-Himalayan belt in the east (27: 126). Minute, epiphyllous cylindrical galls (No. 113), curiously resembling a miniature sea-anemone, are caused perhaps by an aphid on the leaves of *Pirus pashia* Buch.-Ham. in the Kumaon Himalayas in the outer Himalayan floral belt (27: 123, fig. 39, erroneously recorded as *Carya* sp.). Each gall is about 3 mm high, with an apical circular ostiole with a fringe of scaly processes. The galls develop on the periphery of a regular circular patch and are visible on both sides of the leaf blade. On the branches of the same plant in the outer floral belt from the Kumaon and Garhwal Himalayas may occasionally be found gall No. 213 by an unknown midge (25a: 47-48, fig. 16; 27: 140). This is an irregular, multilocular, hard, unilateral cortical growth extending to over 500 mm length of the branches and about 15 mm thick, occurring during the early summer months. A widely distributed gall (No. 422) on leaf of *Prunus cerasoides* D. Don in the outer Himalayan floral belt of the Garhwal Himalayas at about 7000 ft is produced by an unknown species of *Schizoneura* (29: 143, pl. ii, fig. 3). The galls are complex and fleshy masses of greatly enlarged, crumpled and swollen leaves, buds, etc. bright yellow or vivid violet, developing during autumn.

SAXIFRAGACEAE

At elevations of about 7000 ft on the southern aspects of the western Himalayas an unknown midge gives rise to gall No. 496 on leaves of *Deutzia staminea* R. Br. (30: 33). Each gall consists of circular, biconvex, unilocular, utricular, largely epiphyllous beutelgalls, about 4 mm in diameter. A single leaf usually has about half a dozen galls.

CUCURBITACEAE

Cucurbitaceae are as a rule restricted to the Sub-Himalayan floral belt of the Kumaon and Garhwal regions. An unknown species of Lasiopterine midge produces irregular, solid branch galls on *Melothria* sp. (Gall No. 519) in the foot-hills of the Garhwal region during the monsoon rains. Some of the galls grow upto 170 mm length and 25 mm diameter. Reference may also be made to the stem gall on *Cucumis* sp. by *Dacus cucurbitae* Coq. (29: 143), met with at about 5000 ft in the Sub-Himalayan and outer Himalayan floral belts of the Kumaon during the monsoon. While the species normally breeds in the fruits in the plains, it takes to stem-breeding and gall formation in the Himalayas during the season when fruits are absent.

UMBELLIFERAE

At elevations ranging from 7000 ft to about 8000 ft in the outer Himalayan belt of the Garhwal region we come across during early autumn a great abundance of gall No. 515 on ovary of *Heracleum canescens* Lindl. produced by an unknown midge. The galls occur in enormous bunches and greatly resemble fleshy fruits. Each gall is a globose, solid, fleshy, smooth, yellowish-green swelling of the ovary, about 15 mm in diameter. Similar galls are known on different species of *Heracleum* and other related Umbelliferae by the midge *Kiefferia pimpenellae* (Fr. Low) in Europe (22: 326; 38:68, pl. xxxi, fig. 11-13; 36: 159, No. 1227). Umbelliferae galls are so far wholly unknown in the plains of India.

CAPRIFOLIACEAE

Between 7000 ft and 8000 ft in the outer Himalayan floral belt of the Kumaon and Garhwal Himalayas a species of *Eriophyies* produces gall No. 296 on leaf of *Viburnum cotinifolium* Don. This is a subcylindrical, hook-shaped epiphyllous beutelgall, about 5 mm high and common on southern aspects, especially in clearings in *Quercus dilatata* forests. There are two generations of the gall, a pre-monsoon generation commencing from April and a post-monsoon generation maturing about September. (29, 144, pl. ii, fig. 7). On *V. coriaceum* Bl. in the outer Himalayan belt of the Garhwal region we have a rosette gall (No. 442) caused by a midge, and remarkably similar to the rosette gall No. 441 on *Sageretia* *oppositifolia* from the same area. This gall is restricted to *Quercus incana* forests and mostly on the southern aspect of the hills.

RUBIACEAE

Galium mollugo Linn. is extremely widely distributed in the Sub-Himalayan and outer Himalayan belts from the western border of Nepal to the extreme north-west. Two galls are so far known on this plant. Large, solid, fleshy, globose, brown swellings of branches (Gall No. 434), often attaining a size of about 15 mm in diameter, and enclosing 4-5 larval cavities, are produced by an unknown midge after the monsoon rains (29:145; 30:34). This is one of the most abundant galls during July-October, at elevations between 5500 ft and 7500 ft, and especially in old *Quercus incana* formations. During May an isolated example was collected at about 10,000 ft in *Quercus semicarpifolia* forest on the Dholadhar Range. Gall No. 435 is a small fleshy, hollow flower bud gall (29:145) confined to the outer Himalayas during the monsoon rains.

COMPOSITAE

Compositae galls ascend to the alpine Himalayan zone and present certain interesting features. We may recognize a certain amount of Palaearctic facies and in some cases the galls are identical with these in Europe. We have, for example, two extremely interesting galls on *Achillea millefolium* Linn. in the outer Himalayas, occurring above 8500 ft. on the Dholadhar and Pirpanjal ranges. Both these galls are known from Europe (19:867, No. 3152, fig. 1804-1805; 36: 76, 77, No. 56, fig. 10, 11; 37: 288-289, pl. xxiii, fig. 8-11). *Rhopalomyia millefolii* (H. Löw) causes gall No. 527 on leaf, axillary buds and branches (30:34) and *Rhopalomyia* sp. (*millefolii?*) gives rise to gall No. 505 on terminal bud (rosette gall).

A number of *Artemisia* galls are known. Kieffer (21 : 151-153; 19 : 881-882, No. 3194-3196) has recorded from the eastern Himalayas 3 galls, of which gall No. 231 is a globose, spongy, solid and densely tomentose gall on *Artemisia* sp. by the midge *Panteliela hassi* (Kieff.) (27: 143). A curiously similar gall on *Artemisia vulgaris* Linn. is produced by the midge *Misospatha giraldii Kieff.* & Trott. (21a: 233-243; 19: 883, No. 3199), previously known from China, was recently received from Japan. On *Artemisia vulgaris* Linn. I recently collected a somewhat similar but distinct gall (No. 445) on leaf, produced by an unknown midge, is extremely widely distributed at various elevations especially after the monsoon rains, in the Kumaon, Garhwal, Dholadhar and Pirpanjal ranges (29:147; 30: 35). I have also described four other galls on the same plant from the same areas. Two of these are caused by *Eriophyes* spp. respectively on leaf (Gall No. 443) and on inflorescence (Gall No. 455) (30:145-147). An unknown aphid galls (Gall No. 444) the bracts at elevations ranging from 7000 ft to 8000 ft during early autumn. Gall No. 407 is produced by an unknown Lepidoptera on branches in the same floral zones and very similar to the Lepidotera gall on *A. herba-alba* Asso. from Tunis, Algeria and Tripoli (19:877, No. 3172, fig. 1853-1856).

At the bases of the greatly crowded leaves of *Erigeron* sp. an unknown midge gives rise large, fleshy, spongy, solid, cordate galls (No. 514) on buds at 8000 ft in *Quercus incana-Rhododendron* forests in the Garhwal area. This gall again reminds one of the gall of *Macrolabis pilosellae* Binn. on *Hieracium pilosella* (36: 160, No. 1233; 37: 322, pl. ii, fig, 34) from Europe. We have in addition a midge gall (No. 476) on branches of *Inula cappa* DC (29:148) and a leaf-blister gall (No. 521) by *Eriophyes* sp. on *Ainsliaea aptera*. At nearly 14,000 ft I came across irregular, solid branch galls on *Gerbera kunzena* Braun & Asch. during May. This is the highest elevation at which a gall has so far been collected in the Himalayas; it is a midge gall.

ERICACEAE

The large, spongy, solid, hypophyllous gall on leaf of *Rhododendron arboreum* Sm. caused by the fungus *Exobasidium rhododendri* Cam. (29: 148, pl. iii, fig. 3-4, Gall No. 428) is one the most common galls in the whole of the Garhwal and Kumaon regions. This gall is remarkably similar to those of *Exobasidium discoideum* Ell s from South America (35:61) and is perhaps identical with the gall by the same fungus in several parts of Europe (1:209; 41: 45; 36: 246, No. 2273, pl. viii, fig. 173). The gall attains its maximum size at about 8000 ft, where it often measures about 75 mm in diameter during the monsoon rains. An interesting gall by an *Eriophyes* sp. (Gall No. 502) on leaf of *Xolisma ovalifolium* (Wall.) (30:35) comprises bright red, capitate, branched, fleshy and densely crowded epidermal outgrowths, curiously resembling the spores of rust fungi. This gall is usually found at about 7000 ft on the Pangi range.

MYRISINACEAE

Oilgotrophus quadrilobatus Kieff. (21: 151, pl. iii, fig. 3, pl. iv. fig. 4; 19; 704, No. 2525; 27:144, gall No. 234) gives rise to hypophyllous, conical, unilocular galls on leaf midrib of *Maesa perotettiana* A.DC. (*Indica*) in the eastern Himalayas.

SYMPLOCOCEAE

The midge *Contarinia pulcherrima* (Kieff.) causes irregular, woody, button-like galls (No. 236) on branches of *Symplocos theaefolia* D. Don in the eastern Himalayas (21: 148; 19:720, No. 2577; 29: 145; 40: 48, No. 75). From the same area we also know a terminal bud gall (No. 71) by the psyllid *Cecidotrioza baccarum* Kieff. on *Symplocos theaefolia* (21: 159, pl. iv, fig. 12-14). An epiphyllous, discoid beutelgall (No. 72) on the same plant and produced by *Ozotrioza styracearum* Kieff. (21: 179-181, No. 6, fig. 13-14) also occurs in the same region.

OLEACEAE

Stem gall (No. 439) on *Jasminum dispermum* Wall. (29 : 150, pl. iv, fig. 3; 30:36), caused by an unknown midge, and greatly resembling a gall in *Jasminum* sp. from Madagascar (19a : 39), is extremely common and widely distributed throughout the Garhwal and Dholadhar Himalayas, especially at about 5500 ft.

BORAGINACEAE

During early autumn we come across a large number of globose, fleshy galls (No. 516) on ovary of *Cynoglossum micranthum* at about 8000 ft. in the outer Himalayan belt of Garhwal.

ACANTHACEAE

An extremely widely distributed and common gall on leaf of *Strobilanthes dalhousianus* Clarke, at elevations of about 8500 ft. but relatively more common between 6000 ft and 7000 ft, is produced by *Eriophyes* sp. (29 : 150-151, fig. 6, pl. iv, fig. 10; 30 : 36). A species of the fungus *Albugo* causes irregular galls on branches (Gall No. 520) on the same plant in the Garhwal region. Both the galls are features of old *Quercus incana* formations.

AMARANTACEAE

On Dholadhar range at about 10,000 ft is met with an interesting unilateral, solid, irregular dark reddish-brown cortical gall (No. 506) on branches of *Cyathula tomentosa* Moq. by *Eriophyes* sp. (30: 36, pl. viii). This is perhaps the only mite gall collected so far at such a high elevation on the Himalayas. It occurs in openings in *Quercus incana* forests. An unknown midge causes fusiform or globose solid galls (No. 523) on the branches of *Achyranthes aspera* at 8000 ft. in the Garhwal region.

BIGNONIACEAE

Two midge galls are recorded by Kieffer (21 : 154-155) from Kurseong, Eastern Himalayas. Gall No. 250 (27 : 147) is a hypophyllous, globose, pedicellate gall inserted on the midrib or other larger leaf-veins, probably of a plant identified by Sundar Raman (40 : 41) as *Tecoma undulata* G. Don. The second gall (No. 566) by an unknown midge on the branches of the same plant is also reported from the same locality.

POLYGONACEAE

Kieffer (21 : 155- 157, No. 7, fig. 3) records unilateral, irregularly globose galls (No. 256) on the branches of *Polygonum molle* D. Don caused by *Lasioptera textor* Kieff. from Kurseong. Fusiform solid midge galls on branches of *Polygonum amplexicaule* Lindl. (No. 525) were recently collected by me at 8000 ft in Garhwal in early autumn.

LAURACEAE

Lauraceae galls are widely distributed and common. Most of the galls are on leaf and are caused by Itonididae and Psyllidae. Of the 15 galls so far known, 13 are on leaf. Among the midge galls are some that exhibit a remarkable degree of parallel organization in different species of plants. On *Machilus gamblei* King and *M. odoratissima* Nees, for example, we have ovoid, fusiform or conical, solid, fleshy hypophyllous galls, with axial cylindrical larval cavities, produced by different species of midges, the specific characters of which being reflected in the presence or absence of pubescence or other slight differences in shape and size of the galls. Gall No. 260 on *Machilus gamblei* by *Daphnephila hassi* Kieff. from Kurseong (20 : 144-148, pl. ii, figs. 1,5,6,18, 19; 19 : 267-268, No. 969, fig. 556-557) are conical and smooth, while *Neolasioptera* sp. produces on *M. odoratissima* Nees elliptic or fusiform and densely tomentose, rusty-red galls (No. 479) in the western Himalayas (30 : 37, pl. ix) an another unknown species of midge produces in the same region stout, ovoid, smooth, green galls (No. 481). The gall (No. 259) of *Daphnephila glandifex* Kieff. (20 : 148-149, No. 3, pl. ii, fig. 2, 4, 7, 8, 21 : 159; 19 : 267, No. 968, fig. 554-555) on the branches of *M. gamblei* greatly resembles a bunch of gall No. 481. The Psyllid *Neotrioza machili* Kieff. (20 : 176-178, No. 5, fig. 12, pl. ii, fig. 2-9, 14 16; 19:268, No. 970, figs. 558-559) is responsible for epiphyllous, globose unilocular beutelgalls (gall No. 97, Mani, 27 : 120) on leaf of *M. gamblei* in the eastern Himalayas. On *M. odoratissima* we frequently find in the western Himalayas an epiphyllous, cordate, shortly conical, unilocular beutelgalls (No. 482) caused by an unknown psyllid (30 : 38, pl. ix). Some of these galls persist on the plants long after the emergence of the gall insects. Aleurodidae cause epiphyllous pit-galls on *Machilus odoratissima* (Gall No. 495) (30 : 38, pl. viii) and on *Phoebe lanceolata* Nees (Gall No. 440) 29 : 152; 30 : 38, pl. viii) in the Dholadhar and Garhwal Himalayas. The tingid bug *Stephanitis gallarum* Horv. (18 : 33) causes a very common leaf gall (27 : 110, No. 322) on *M. gamblei* King in Kurseong.

Eriophyes sp. causes epiphyllous beutelgalls (27 : 105, No. 32) on leaf of *Lindera assamica* Kurz in the eastern Himalayas (9 : 427; 20 : 198). From the same area *Eriophyes linderae* Corti (9) causes oval or conical, solid galls (27 : 105, No. 33) on leaf veins of *Lindera pulcherrima* Benth. (20 : 196, fig. 15; 19 : 274, No. 996). An unknown psyllid is responsible for leaf roll gall (27 : 119, No. 95) on *Lindera assamica* (20 : 181-182, No. 8; 19-274, No. 997). On *Lindera pulcherrima* we also find globose, epiphyllous, thick-walled unilocular galls (27 : 118, No. 258) caused by the midge *Daphnephila linderae* Kieff. (20 : 181, No. 7; 19 : 272, No. 999). The psyllid *Ozotrioza laurinearum* Kieff. (20 : 181) gives rise to subconical galls (27 : 118, No. 86) along the midrib (19 : 272, No. 990) and another unknown psyllid causes broad, agglomerate galls (27 : 118, No. 87) on branches of *Beilschmiedia sikkimensis* King (40 : 11), in the Sikkim-Himalayas.

EUPHORBIACEAE

We know as yet only a single gall on branches of *Cyclostemon assamicus* Hook. produced by the midge *Clinodiplosis nodifex* Kieff. (27 : 150, No. 261; 19 : 908, No. 3286) from the eastern Himalayas.

ULMACEAE

The common Himalayan elm *Ulmus wallichiana* Planch. has two aphid galls. Gall No. 112 is an irregular hollow leaf gall, very similar to the galls of *Schizoneura ulmi* on the European elm *U. campestris*. This gall is common during summer in the north-west Himalayas (27 : 123, fig. 70, provisionally named as *U. campestris*). Another aphid close to, if not identical with, the European *Byrsocrypta* (-*Tetraneura ulmi*) *gallarus* (36 : 290, No. 3844, fig. 230-231) produces epiphyllous, clavate, lop-sided, utriculate beutelgalls (30 : 39, pl. ix), which burst open irregularly on one side near the base. (Gall No. 493). Numerous predatory thrips occur within several of these galls. The gall is abundantly distributed during summer at about 8000 ft.

MORACEAE

Of the five common galls, gall No. 426 on leaf of *Ficus foveolata* Wall. (29 : 152, pl. iv, fig. 4-5; 30 : 38) is produced by an unknown midge in the Kumaon, Garhwal and on the Pirpanjal and Dholadhar Ranges, between 6000 ft and 8000 ft, especially in moist and sheltered sides of the hills. The galls are solid, fleshy hemispherical operculate beutelgalls, crowded in large numbers on leaf. In the western Himalayas at about 7000 ft we find another extremely common gall, caused by *Eriophyes* sp. on leaf of *Ficus scandens* Roxb., with dense, pink hypophyllous erineum, often as many as 500 galls on a single leaf (30 : 39, pl. x, gall No. 480). Three other galls are caused by Psyllidae, of which *Pauropsylla* sp. is associated with the more common gall No. 81 on leaf of *Ficus roxburghi* Wall. (29 : 152; 30 : 39; 27 : 117; 31 : 50) on the foot-hills between 5000 ft and 7000 ft, along the edge of the Himalayas from the Kumaon to the north-west. From the eastern Himalayas, Kieffer (20 : 169-173; 19: 175-176, Nos. 627 & 628; 27 : 116-117) describes obtusely conical beutelgalls (No. 77) by *Pauropsylla ficicola* Kieff. and globose beutelgalls (No. 78) by *P. globuli* Kieff. on leaf of *Ficus hookeri* Roxb.

URTICACEAE

One of the most interesting and fairly common galls occurring between 7000 ft and 8500 ft in the Garhwal region is a delicate, membranous, hollow, white, smooth, elongate-conical, epiphyllous psyllid beutelgall (29 : 154, pl. iv. fig. 1-2) on leaf of *Lecanthus wightii* Wedd. This gall is found only during the monsoon rains and not more than 3-4 on a single leaf. It is one of the few psyllid galls, which have a permanently wide open hypophyllous ostiole and does not dehisce. On the leaves of the equally common *Boehmeria platyphylla* Don an unknown midge causes globose, reddish-brown beutelgalls visible equally on both sides of the blade (29 : 153, No. 446). This gall occurs only in Kumaon and Garhwal Himalayas.

FAGACEAE

Thirteen galls are so far known. An unknown midge causes an extremely interesting gall (No. 293) on leaf of *Quercus incana* Roxb. in the outer Himalayas upto nearly 8000 ft, but relatively more commonly at lower elevations. It is a solid hard, shortly-petiolate gall on under side of leaf, with an axial larval cavity, containing one or two larvae. Though it is the only midge gall collected so far on Himalayan, oaks it has not been possible to rear the adult midges. There is apparently a single generation, with the adults probably appearing in April, but the galls mature slowly till the beginning of winter. Itis one of the commonest galls at elevations of about 5000 ft in old and dense forests. It occurs throughout the Kumaon, Garhwal, west and north-western Himalayas. (27 : 152; 29 : 156, pl. iii; 30 : 41).

There are four cynipid galls on leaves, three on buds and branches on oaks. Two leaf galls are also caused by *Eriophyes* spp. On the Himalayan white oak *Quercus incana Eriophyes* sp. produces gall No. 292. Gall No. 449 is a button-shaped cynipid leaf gall (29 : 156; 30 : 41). Gall No. 433 is a hypophyllous reddish cynipid gall crowded in large numbers on midrib (29 : 157, pl. iii). The only branch gall by cynipid is gall No. 294 (27 : 156, fig. 36). Gall No. 421 is a large, globose, multilocular, spongy, reddish-brown compound bud gall (29 : 158, pl. iv, fig. 7; 30 : 41); this gall is widely distr buted and is particularly common at 8000 ft.

On *Querous dilatata* there is a cynipid bud gall (No. 501) very similar to gall No. 421 of *Q. incana* and occurs at about 7500 ft (30 : 40). Gall No. 450 is a solid, hemispherical, multilocular leaf gall by cynipid restricted to about 8000 ft in Kumaon and on the Dholadhar (29 : 156, pl. iv, fig. 6; 30 : 40). *Eriophyes* sp. gives rise to a gall (No. 448) , somewhat like gall No. 292 (on Q. incana) in the western Himalayas (30 : 40).

On the high altitude oak *Quercus semicarpifolia* Smith we have acorn galls (Gall No. 283) caused by the cynipid *Callirhytis semicarpifoliae* Cam. in the extreme north-west Himalayas (6 : 38; 19 : 151, No. 542; 11 : 563). *Neuroterus hassi* Kieff, (19b : 61; 20 : 182; 11 : 326; 19 :1 151, No. 541; 27 : 156) produces unilateral subglobose, multilocular, branch galls (No. 284) on *Q. spicata* Smith in the eastern Himalayas. Large irregularly tuberculated multilocular spongy solid galls on leaf blade of *Q. pachyphylla* Kurz (Gall No. 282) are caused by an unknown cynipid in the same area (20 : 182; 19 : 141, No. 540; 27 : 156). An interesting pinecone-like terminal bud gall of *Q. griffithii* Hook. by an unknown cynipid comes from the Sub-Himalayan belt of the eastern Himalayas (27 : 156, fig. 29).

JUGLANDACEAE

The pustule galls on leaf and fruits of *Juglans regia* Linn. caused by *Eriophyes tristriatus* Nalepa (37 : 268; 19 : 75, No. 188; 36 : 167, No. 1337) and known to be widely distributed in Europe, Persia, Afghanistan and Asia Minor, has also been collected at various elevations ranging from 6000 ft to 7000 ft in the Kumaon Himalayas (29 : 154).

SALICACEAE

Nine galls, the majority of which are caused by aphids, are so far known. Five aphid galls on Himalayan *Populus* are of fairly common occurrence. *Pemphigus immunis* Buckton (40 : 15, No. 38; 27 : 124, No. 118) causes woody galls on twigs of *Populus nigra pyramidalis* near Gilgit in the north-west Himalayas, at about 4000 ft. to 5000 ft. The four other galls are on the common Himalayan popular *Populus ciliata* Wall. *Pemphigus napeus* Buckton (40:15, No. 37; 27:124) causes globose unilocular galls (No. 117) on twigs of *P. ciliata* at about 9000 ft in the Pirpanjal and Dholadhar Ranges. Gall No. 114 on the same plant is an extremely interesting, fleshy, but hard, elongate, stout, thick-walled, yellow gall on leaf, curiously looking like a stout caterpillar of Spingid moth. It is caused by the aphid *Pemphigus imaicus* Cholod. (7:495; 19:82, No. 215, fig. 139; 27 : 123, fig. 76; 30 : 41, pl. x). This gall often attains giant sizes, exceeding 75 mm long. It is widely distributed on the Dholadhar and Pirpanjal as well as Pangi Range at about 7000 ft. to 85000 ft. Inside old specimens of gall No. 115 on the branches of the same plant and caused by *Pemphigus mordwilkowi* Cholod. (7 : 493; 19 : 82, No. 213; 123, fig. 75; 30 : 42, pl. x) and also common enough on the same region, we frequently find about dozen adults of *Coccinella septempunctata* Linn. at 8000 ft. Gall No. 116 by *Pemphigus nainitalensis* Cholod. is a somewhat smaller gall on branches in the Kumaon Himalayas at about 6000 ft. An unknown midge produces enormous numbers of hard, solid, pale yellow galls on leaf of *Salix daphnoides* Willars (Gall No. 418) at 7000 ft in the Garhwal Himalayas (29: 155). The adult midges appear to emerge in April and the galls mature in late autumn, but the emergence of the adult is delayed till next spring. The only other midge gall on Himalayan willows is a solid, fusiform, hard, branch gall (No. 268) on *Salix elegans* Wall. by *Oligotrophus saligneus* Coq. at about 9000 ft in Terai-Garhwal Himalayas (8; 26 : 439; 27 : 151). On the same plant I recently collected subglobose, epiphyllous mite galls (No. 492) between 6000 ft and 7000 ft in the southern spurs of the Pirpanjal ranges of the western Himalayas (30 : 42). *Pontania* sp. causes large hollow gall (No. 575) on *Salix fragilis* in the Chenab Valley.

CONIFERAE

Two fir-cone-like galls are recorded on the Himalayan spruce *Picea (morinda) smithiana* Bois. by *Chermes* spp. at 8000 ft to 9000 ft in the west and north-western Himalayas (27 : 124). An unknown midge causes gall No. 269 on needles of *Pinus longifolia* Roxb. in several localities in Himalayas (39 : 420; 19 : 27, No. 31; 27 : 151).

ACKNOWLEDGMENTS

I have great pleasure in recording my heart-felt thanks to Messrs Santokh Singh and H. N. Baijal, two of my esteemed Research Associates. The former in particular accompanied me on many occasions in the field, deep into the wild interior of the Himalayas and collected many valuable specimens for me. I am also greatly indebted to my first son M. Visvanath for help in the field and to my wife for collection of numerous specimens. The trips in the Dholadhar and

Pirpanjal ranges were made possible entirely through the help and assistance of Mr. Tej Bhan Singh Saini, Range Officer, Forest Department, Kangra. The plant specimens were identified by Mr. M. B. Raizada, Systematic Botanist, Indian Forest Research Institute, Dehra Dun.

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ON A NEW SPECIES OF *CHELONUS* (BRACONIDAE : PARASITIC HYMENOPTERA) FROM INDIA[1]

By V. K. Gupta, M. Sc., F. R. E. S., *Research Associate, School of Entomology, St. John's College, Agra.*

I thank Prof. M. S. Mani for placing the specimens of this species at my disposal and for guidance.

Chelonus heliopae, sp. nov.

Female.—length 3.7 mm. *Head* viewed from above sub-quadrate, twice as wide as long, not wider than thorax between tegulae; temples receding from eyes; interocellar space equal to ocellocular space. Vertex not margined behind; vertex and occiput rugose. Viewed in front (Fig. 2) somewhat ovate, slightly wider than long. Clypeus rugose, a little convex, nearly twice as long as broad, pubescent. Antennae with 16 segments, testaceous basally, but brownish-black apically; basal segments as in fig. (1), segments 11-15 not longer than thick. Eyes large, oval, pubsecent.

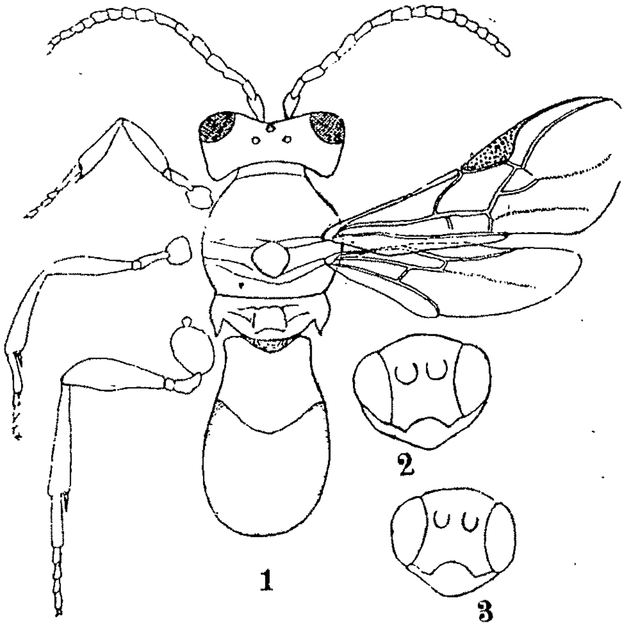

Fig. 1. *Chelonus heliopae*, sp. nov. female
Fig. 2. *Chelonus heloopae*, sp, nov. female Head viewed from front.
Fig. 3. *Chelonus heloopae*, sp. nov. Male Head viewed from front.

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[1] Contribution No. 58 from the School of Entomology, Agra; published with the permission of the Professor of Zoology and Entomology.

Thorax robust, rugose, relatively sparsely pubescent; mesonotum entire, finely closely punctate in the middle in front and coarsely and largely punctate behind and laterally, deeply separated from the scutellum; scutellum convex, more or less pyramidal, with a few fine scattered punctae in the middle, coarsely punctate at the sides; mesopleurae roughly punctate.

Propodeum nearly two and a half as broad as long, coarsely reticulately sculptured, prominently margined posteriorly, imperfectly areolate, laterally with conspicuous tooth-like projections behind.

Legs : Coxae globose, tarsi 5 jtd., claws simple. Fore and mid femur, tibiae and tarsi equal in length; hind tibia a little longer than its femur; hind tarsi equal to hind tibiae; first tarsal segment of all legs nearly half of their femur; last tarsal segment nearly half of the first tarsal segment.

Wings hyaline, pubescent; fore wing length nearly two and a half the breadth; pterostigma black, thrice as long as broad; vein *r* emerging from the middle of pterostigma. R_5 , M_1 , & $m-M_2$ faintly represented; M_4-Cu_1 and M_3 not touching the anal vein; 1st Cu and radial cells fused. Hind wings nearly three times as long as broad. Rest of venation as in fig. (1).

Abdomen broadly sessile; the abdominal tergites fused to form a single structure covering whole of abdomen, devoid of sutures; abdomen a little shorter than the head and thorax combined and a little narrower than the thorax, coarsely longitudinally striated, apex rounded and covered with hairs. Ovipositor distinctly exserted.

Body colour.—Head and thorax black; fore and mid legs yellowish-brown with their apical tarsi and claws testaceous black; coxae black; hind coxa, trochanter and femur blackish-brown; hind tibia blackish basally and apically, yellowish in the middle; hind tarsi testaceous, the apical portion blackish. Basal half of the abdominal tergite yellowish-white, apical half black.

Male like female except that clypeus more convex than in female; antennae with 26 segments, nearly as long as the head, thorax and abdomen combined; face one and two-third as wide as long. (Fig. 3).

Holotype female, Allotype male, Paratypes males and females reared from larvae of *Gnorimoschema* (*Phthorimaea*) *heliopa* (L.) boring in stem of tobacco, Annand. Received from Dr. H. K. Patel, Institute of Agriculture, Annand. In the collections of the Zoological Survey of India, Calcutta.

This species differs from *Chelonus phthorimae* Gahan[1], parasitic on *Gnorimoschema operculella* (Zeller), in the different body colouration, antennae with 26 segments in male, reticulate propodeum, with only a single pair of latero-posterior tooth, hind tarsi being equal to hind tibiae and other characters.

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[1] Gahan, A. B. 1917. *Proc. U. S. Nat. Mus.*, **53** (2197): 199.

Ramakrishna Ayyar[1] has recorded an unnamed species of *Chelonus* as parasitic on the same host in South India. The present species may prove to be same as observed by him.

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CATALOGUE OF ORIENTAL ITONIDIDAE (=CECIDOMYIIDAE: DIPTERA)*

By S. N. RAO, M. Sc., Ph. D., F. R. E. S., *Lecturer in Zoology, College of Science, Nagpur (formerly Research Associate, School of Entomology, St. John's College, Agra)*

This catalogue attempts to bring the references to the Oriental Itonididae up to date and should replace the earlier catalogues of van der Wulp (1889) Brunetti (1920) and Sernior-White (1928).

I am greatly indebted to Prof. Dr. M. S. Mani, Professor of Zoology & Entomology, School of Entomology, St. John's College, Agra, for placing at my disposal the material collected by him for a revised catalogue of the family, for guidance and facilities for work.

Subfamily LESTREMIINAE Rondani

Lestreminae, RONDANI, *Spora. Alc. Gen. Insect. Ditt., Mem. Sec. Serv. Ditt. Ital.* (review in Isis von Oken 1844 : 450), 1840; *Prog. Classif. Fam. Inset. Ditt. Eur., Mem. Terza. Serv. Ditt. Ital.* (review in Isis von Oken, 1843 : 617), 1841; *Nuov. Ann. Sci. Nat. Bologna*, (2) 6 : 367 (1846); *Nuov. Ann. Sci. Nat. Bologna*, (2)7 : 21 (1847). SCHINER, *Fauna Austr., Flieg.*, 2 : 19 (1864); *Reise Öster-Freg. Nov.*, 2 : 5 (1868). WINNERTZ, *Verh. zool.-bot. Ges. Wien*, 20; 9 (1870). BERGENSTAMM & LÖW, *Verh. zool.-bot. Ges. Wien*, 26 : 17 (1877). VAN DER WULP, *Dipt. Neerl.*, p. 45, (1889). THEOBALD, *Acc. Brit. Flies*, 3 : 86 (1892). KIEFFER, *Bull. Soc. Hist. Nat. Metz*, (2) 8 : 47 (1898); *Ann. Soc. Ent. France*, 69 : 450 (1900). WILLISTON, *Mon. Dipt. N. Amer.*, 3rd edit., pp. 127, 130 (1908). KIEFFER, *Gen. Ins.*, 152 : 284 (1913).

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Tribe MICROMYINI Rondani

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bengalensis Kieffer

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2. **Trichopteromyia** Williston

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manii Nayar

Trichopteromyia manii, NAYAR, *Indian J. Ent.*, 6 : 69 (1944)[1]; *Proc. Indian Acad. Sci.*, 26 (6), : 233 (1947)[2]. — [1], [2]Trivandrum

3. **Micromya** Rondani*

Micromya, RONDANI, *Sopra Alc. Gen. Inset. Ditp.*, *Mem. Sec. Serv. Ditt. Italy*, p. 21 (1840) [Genotype : *Micromya lucorum* Rondani]. *Nuov. Ann. Sci. Nat. Bologna*, (2) 6 : 373 (1846); *Dipt. Italy, Prod.*, 1 : 193 (1856). PRITCHARD, *Ent. Americana.*, 27(2) : 60 (1947).

Micromyia, RONDANI, (emendation for *Micromya*) : review of Rondani's 1840 paper, Isis von Oken, p. 451 (1844). WINNERTZ, *Verh. Zool.-bot. Ges. Wien.*, 20 : 26 (1870). VAN DER WULP, *Dipt. Nerrl.* p. 78 (1877). KIEFFER, *Misc. Ent.*, 3 : 112 (1895); *Bull. Soc. Hist. Nat. Metz.*, (2) 8 : 50 (1898); *Ann. Soc. Ent. France*, 69 : 441 (1900). FELT, *J. N. Y. ent. Soc.*, 19 : 34 (1911). ENDERLEIN, *Arch. Naturg.*, 77 (Bd. 1, suppl. 3): 196 (1911). KIEFFER, *Gen. Ins.*, 152 : 294 (1913). FELT, *Bull. N. Y. St. Mus.*, 165 : 163 (1913); *Ibid.* 257 : 137 (1925); *Lingnan Sci. J.* 7: 426 (1929). EDWARDS, *Proc. R. ent. Soc. London.*, 7 (B) : 254 (1938). MANI, *Indian J. Ent.*, 7 : 193 (1946).

Ceratomyia, FELT, *J. N. Y. ent. Soc.*, 19: 33 (1911); *Bull. N. Y. St. Mus.* 165 : 162 (1913). KIEFFER, *Gen. Ins.*, 152 : 317 (1913). (New synonymy).

Crespiniella, KIEFFER, *Broteria*, 21 (ser. Zool.) : 88 (1924) (New synonymy).

indica Mani

Micromya (*Micromyia*) *indica*, MANI, *Rec. Indian Mus.*, 39 (3): 281 (1937)[1]. — [1]Calcutta, New Delhi.

4. **Mycophila** Felt

Mycophila, FELT, *J.N.Y. ent. Soc.*, 19 : 33 (1911) [Genotype: *Mycophila fungicola* Felt]; *Bull. N. Y. St. Mus.*, 165 : 161 (1913). KIEFFER, *Gen. Ins.*, 152 : 288 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 137 (1925). BARNES, *Ent. Mon. Mag.*, (3) 63 : 164 (1927). FELT, *Lingnan Sci. J.*, 7 : 426 (1929).

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*Pritchard (1947, *op. cit.*) has drawn attention to the fact that Rondani spelt the genus *Micromya* and not *Micromyia* consistently. The original spelling must be retained.—*M. S. Mani.*

EDWARDS, *Proc. R. ent. Soc., London.*, 7 (B) : 253 (1938). MANI, *Indian J. Ent.*, 7 : 191 (1946). PRITCHARD, *Ent. Americana*, 25 (2) : 64 (1947).

indica Nayar

Mycophila indica, NAYAR, *Proc. R. ent. Soc., London*, (B) 18 (5-6) : 81 (1949)[1]

Tribe CATOCHINI Edwards

Catochini, EDWARDS, *Proc. R. ent. Soc., London*, 7 (B) : 24 (1938). PRTICHARD, *Ann. ent. Soc. America*, 40 (4) : 663 (1947).

Catochariae, MANI, *Indian J. Ent.*, 7 : 191 (1946).

5. **Catocha** Haliday

Catocha, HALIDAY, *Ent. Mag.*, 1 : 156 (1833) [Genotype; *Catocha latipes* Haliday]. MACQUART, *Hist. Nat. Insect, Dipt.*, 2 : 654 (1835). WESTWOD, *Intro. Classif. Insects, Gen. Syn.*, p. 127 (1840). WALKET *Insect, Brit. Dipt.*, 3 : 59 (1856). OSTEN SACKEN, *Mon. N. Amer. Dipt.*, 1 : 177 (1862). SCHINER, *Fauna Austr., Flieg.*, 2 : 412, (1864). WINNERTZ, *Verh. Zool.-bot. Ges. Wien.*, 20 : 27 (1870). VAN DER WULP, *Dipt, Neerl.* p. 78 (1877). SKUSE, *Proc. Linn. Soc. N. S. Wales*, 3 : 143 (1889). KIEFFER, *Bull. Soc. ent. France*, p. 319 (1895); *Bull. Soc. Hist. Nat. Metz.*, (2) 8 : 52 (1898); *Ann. Soc. ent. France*, 69 : 438 (1900). FELT, *Bull. N. Y. St. Mus.*, 124 : 308 (1908); *J. N. Y. ent. Soc.*, 19 : 31 (1911). ENDERLEIN, *Arch. Naturg.*, 77 (Bd. 1, Suppl. 3) : 192 (1911). FELT, *Bull. N. Y. St. Mus.*, 165 : 129 (1913). KIEFFER, *Gen. Ins.*, 152: 306 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 136 (1925); *Lingnan Sci. J.*, 7 : 425 (1929). EDWARDS, *Ent. Mon. Mag.*, 65 : 10 (1929). MANI, *Rec. Indian Mus.*, 36 : 378 (1934). EDWARDS, *Proc. R. ent. Soc., London*, 7 (B) : 104 (1938). MANI, *Indian J. Ent.*, 7 : 192 (1946). PRITCHARD, *Ann. ent. Soc. America*, 40 : 667 (1947).

Mimosciara, RONDANI, *Sopra Alc. Gen. Insect, Ditt. Mem. Soc. Serv. Ditt. Italy*, 1840, [reviewed in Isis von Oken, 1844, p. 451]; *Nuov. Ann. Sci. Nat. Bologna*, (2) 6 : 372 (1846). BIGOT, *Ann. Soc. ent. France*, (3) 2 : 475 (1854). KIEFFER, *Bull. Soc. ent. France*, 69 : 442 (1900). COQUILLETT, *Proc. U. S. Nat. Mus.*, 37 : 570 (1910). EDWARDS, *Ent. Mon. Mag.*, 65 : 10 (1929).

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[1] Trivandrum

Furcinerva, Rondani, *Nuov. Ann. Sci. Nat. Bologna*, (2) 6: 369 (1846) [based on the union of *Zigoneura*, *Lestremia*, *Mimosciara and Catocha*]. Bigot, *Ann. Soc. Ent. France*, (3) 2 : 461 (1854). Kieffer, *Bull. Soc. ent. France*, 69 : 443 (1900). Coquillett, *Proc. U. S. Nat. Mus.*, 37 : 545 (1910).

Macrostyle, Winnertz, *Ent. Ztschr. Ent. Ver Stettin*, 7 : 20 (1846). Bigot, *Ann. Soc. ent. France*, (3) 2 : 461 (1854).

Molobraea,* Löw, *Dipt. Beitr.*, 4 : 12, 20 (1850) (a manuscript name of Rondani's based on the union of *Catocha*, *Lestremia*, *Mimosciara* and *Anarete*). Bigot, *Ann. Soc. ent. Jrance*, (3) 2 : 462 (1854) (as *Molobrea*).

Molobraea (Molobraea) Löw, *Dipt. Beitr.*, 4 : 22 (1850), (based on the union of *Lestremia* and *Mimosciara*).

Molobraea (Catocha), Löw, *Dipt. Beitr.*, 4 : 22 (1850).

Yopsatoea, Rondani, *Dipt. Ital. Prod.*, 1 : 198 (1856 (Based on the union of *Lestremoa*, *Zigoneura*, and *Mimosciara*); Coquillett, *Proc. U. S. Nat. Mus.*, 37 : 621 (1910).

indica Mani

Catocha indica, Mani, *Rec. Indian Mus.*, 36 : 378 (1934)[1].

[1] N.W.F. Province: (Now Pakistan)

Tribe Lestremiini Kieffer

Lestremides, Kieffer, *Bull. Soc. Nat. Hist. Metz.*, (2) 8 : 52 (1898).

Lestremiariae, Kieffer, *Ann. Soc. Ent. France*, 69 : 451 (1900); *Gen. Ins.*, 152 : 305 (1913).

Lestremiinariae, Felt, *Bull. N. Y. St. Mus.*, 124 : 308 (1908); *Bull. N. Y. St. Mus.*, 165 : 125 (1913); *Philipp. J. Sci.*, 13(D) : 296 (1918); *Bull. N. Y. St. Mus.*, 257 : 136 (1925); *Lingnan Sci. J.*, 7 : 425 (1929). Mani, *Rec. Indian. Mus.*, 36 : 378 (1934); *Indian J. Ent.*, 7 : 191 (1946).

Lestreminariae, Felt, *J. N. Y. ent. Soc.*, 19 : 31 (1911).

Lestremiini, Enderlein, *Arch. Naturg.*, 77 (Bd. 1, Suppl. 3): 189 (1911); *Zool. Anz.*, 40; 269 (1912). Edwards *Proc. R. ent. Soc. London.*, 7 (B): 24 (1938). Pritchard, *Univ. Calif. Publ. Ent.*, (8) 6 : 241 (1951).

Lestremiinae, Enderlein, *Tierwelt Mitteleur.*, 6 (Lief. 2, Teil 3): 59 (1936).

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*According to Neave's "Nomenclator Zoologicus" *Molobraea* was described in Löw's "Ueber den Bernstein und die Bernsteinfauna (Dipteren)", p. 32, published in Berlin, 1850.

6. **Anarete** Haliday

Anarete, HALIDAY, *Ent. Mag.*, 1:156 (1833) [Genotype: *Anarete perplexa* (Felt)]. MACQUART, *Hist. Nat. Insect. Dipt.*, 2 : 653 (1935). WESTWOOD, *Introd. Classif. Insect.*, *Gen. Syn.*, p. 127 (1840). Löw, *Ent. Ztschr. ent. Ver. Stettin*, 6 : 396 (1845). WALKER, *Ins. Brit.*, *Dipt.*, 3 : 60 (1856). SCHINER, *Fauna. Austr.*, *Flieg.*, 2 : xvii, 353 (1864). OSTEN SACKEN, *Berl. ent. Ztschr.*, 37: 451 (1893). KIEFFER *Ann. Soc. ent. France*, 69 : 434 (1900); *Ann. Soc. Sci. Bruxelles*, 30: 338 (1906). ENDERLEIN, *Stettiner ent. Zeitung*, 72 : 130 (191); *Arch. Naturg.*, 77 (Bd. 1, Suppl. 3) : 194 (1911). EDWARDS, *Insect. Somoa*, 6: 29 (1928); *Ent. Mon. Mag.*, 65:13 (1929); *Proc. R. ent. Soc. London*, 7 (B): 28 (1938). PRITCHARD, *Univ. Calif. Publ. Ent.*, 8 (6):258 (1951).

Molobraea (*Anarete*), Löw. *Dipt. Beitrag.*, 4:32 (1850).

Anarete (*Pseuanarete*), KIEFFER, *Ann. Soc. Sci. Bruxelles*, 30 : 342 (1906).

Microcerata, FELT, *Bull. N. Y. St. Mus.*, 124:308 (1908): *J. N. Y. ent. Soc.*, 19 : 32 (1911); *Bull. N. Y. St. Mus.*, 165: 142 (1913). KIEFFER, *Gen. Ins.*, 152: 309 (1913). Edwards. *Insect Samoa*, 6 : 39 (1928). MANI, *Rec. Indian Mus.*, 36: 381 (1934).

Limnopneumella, ENDERLEIN, *Arch. Naturg.*, 77 (Bd. 1, Suppl. 3) : 195 (1911).

Limnopneuma, ENDERLEIN, *Arch. Naturg.*, 77 (Bd. 1. Suppl. 3) : 196 (1911).

manii Rao

Anarete manii, RAO, *Rec. Indian Mus.*, 50 (3-4): 307 (1953)[1]. [1]Agra

7. **Conarete** Pritchard

Conarete, PRITCHARD, *Univ. Calif. Publ. Ent.*, 8 (6) : 255 (1951) [Genotype : *Conarete crebra* Pritchard].

calcuttaense (Nayar)

Anarete calcuttaense, NAYAR, *Proc. R. ent. Soc. London*, (B) 18 (5-6) : 79 (1949)[1]. [1]Calcutta

*Conarete calcuttaense**, PRITCHARD, *Univ. Calif. Publ. Ent.*, 8 (6) : 255 (1951).

indica (Mani)

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*Pritchard (1951) records that this species is probably a synonym (?) of *C. indica* (Mani)

Microcerata indica, MANI, *Rec. Indian Mus.*, 36 (4) : 382 (1934)[1]. [1]Satara Dist.

Anarete indica, NAYAR, *Proc. R. ent. Soc. London*, (B) 18 (5-6) : 81 (1949).

Conanarete indica, PRITCHARD, *Univ. Calif. Publ. Ent.*, 8 (6) : 255 (1951).

8. **Lestremia** Macquart

Lestremia, MACQUART, *Insect. Dipt. Nord. France*, pt. 1, Tipul. p. 173 (1826) [Genotype: *Lestremia cenera* Macquart]. MEIGEN, *Syst. Beschr. bekann. europ. zweifl. Insekt.*, 6 : 308 (1830). MACQUART, *Hist. Nat. Insect.*, 1 : 157 (1834). WESTWOOD, *Introd. Classif. insects*, *Syn. Gen.* p. 127 (1840). WALKER, *Insect Brit. Dipt.*, 3 : 57 (1856). SCHINER, *Fauna. Austr., Flieg.*, 2: 413 (1864). WINNERTZ, *Verh. Zool. - bot. Ges. Wien.*, 3 : 144 (1870). VAN DER WULP, *Dipt. Neerl.*, p. 80 (1877). SKUSE, *Proc. Linn. Soc. N. S. Wales*, 3 : 144 (1889). KIEFFER, *Bull. Soc. Hist. Nat. Metz.*, (2) 8 : 52 (1898); *Bull. Soc. ent. France*, 69 : 437 (1900). FELT, *Bull. N. Y. St. Mus.*, 124 : 310 (1908); *J. N. Y. ent. Soc.*, 19 : 31 (1911). ENDERLEIN, *Arch. Naturg.*, 77 (Bd. 1, Suppl. 3) : 191 (1911). FELT, *Bull. N. Y. St. Mus.*, 165:129 (1913). KIEFFER, *Gen. Ins.* 152: 307 (1913). EDWARDS, *Ent. Mon. Mag.*, 65:11 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 379 (1934). EDWARDS, *Proc. R. ent. Soc. London.* 7 (B) : 25 (1938). PRTICHARD, *Univ. Calif. Publ. Ent.*, 8 (6): 244 (1951).

Lestremia (Cecidogona), LÖW, *Ent. Zeitschr. ent. ver. stettin*, 5 : 324 (1844). WINNERTZ, *Verh. Zool. bot. Ges. Wien*, 20 : 25 (1870).

Cecidogona, LÖW; WALKER, *Insect. Brit. Dipt.*, 3 : 58 (1856). LÖW, *Monog. N. Amer. Dipt.*, 1 : 7 (1862). SKUSE, *Proc. Linn. Soc. N. S. Wales*, 3:144 (1889). KIEFFER, *Bull. Soc. ent.* France, 69: 443 (1900).

indica Kieffer

Lestremia indica, KIEFFER, *Rec. Indian Mus.*, 3 : 129 (1909)[1]; *Gen. Ins.*, 152 : 308 (1913)[2] BRUNETTI, *Rec. Indian Mus.*, 17 : 18 (1920)[3]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 19 (1928)[4]. FELT, *Lingnan Sci. J.*, 7 : 460 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 379 (1934)[5]. [1,3,4,5]Calcutta [2]E. Indies

ceylonica Kieffer

Lestremia ceylonica, KIEFFER, *Spol. Zeyl.*, 8: 29 (1912)[1] BRUNETTI, *Rec. Indian Mus.*, 17 : 18 (1920)[2]. SENIOR-WHITE, *Cat., Indian Ins.*, 15 : 19 (1928). Felt, *Lingnan Sci. J.*, 7 : 460 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 380 (1934)[3]. [1,2,3]Paradeniya [3]trichinopoly

calcuttaensis Mani

Lestremia calcuttaensis, MANI, *Rec. Indian Mus.*, 39 (3) : 281 (1937)[1]. [1]Calcutta

sancti-johanni Rao

Lestremia sancti-johanni, RAO, *Indian J. Ent.*, 11 (2) 109 (1951)[1]. [1]Agra

9. **Neolestremia** Mani

Neolestremia, MANI, *Rec. Indian Mus.*, 36 (4) : 380 (1934) [Genotype: *Neolestremia boerhaaviae* Mani]; *Indian J. Ent.*, 7 (1-2):191 (1946).

boerhaaviae Mani

Neolestremia boerhaaviae, MANI, *Rec. Indian Mus.*, 36 (4): 380 (1934)[1] [ex gall No. on *leaf* bud of *Boerhaavia* sp. (Nyctagenaceae)]. [1]Madras

Subfamily HETEROPEZINAE

Heteropezinae, KIEFFER, *Gen, Ins.*, 152 : 15 (1913). FELT, *Bull. N. Y. St. Mus.*, 257:138 (1925); *Lingnan Sci. J.*, 7 : 424,427 (1929). MANI, *Rec. Indian Mus.*, 36 (4):377 (1934); *Indian J. Ent.*, 7 (1&2): 190, 1946.

Heteropezidae, ESSIG, *College. Ent.*, p. 736 (1942).

10. **Meinertomyia** Felt

Pero, (*pre-occ. Pero*, Sachaffer), MEINERT, *Naturalist Fidsskr. Copenhagen*, (3) 4 : 463 (1870). KIEFFER, *Synop. Cecid. Europe et Algerie*, p. 54 (1898).

Meinertomyia, FELT, *J. N. Y. ent. Soc.*, 19 : 37 (1911) [Genotype: *Meinertomyia fasciata* (Meinert)]; *Bull. N. Y. St. Mus.*, 147 : 85 (1911); ibid., 165 : 214 (1913). KIEFFER, *Gen. Ins.*, 152 : 315 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 139 (1925); *Lingnan Sci. J.* 7:423 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 425 (1934); *Indian J. Ent.*, 7: (1&2); 195 (1946).

aequipalpis Mani

Meinertomyia aequipalpis, MANI, *Rec. Indian Mus.*, 37 (4): 426 (1935)[1] [ex gall No. on *Ficus rumphii Blume*]. [1]Dehra Dun

inaequiplapis Mani

Meinertomyia inaequipalpis, Mani, *Rec. Indian Mus.*, 37 (4) : 426 (1937)[1] [ex gall No. on *Odina wodier Roxb.*, ex gall shoots of Bamboo; ex gall No. on *Buchnamia latifolia Roxb;* ex gall No. on *Polyantha simiarum;* ex gall No. on *Morus alba Bureau.*]
[1]Assam, U. P., C. P., Bengal, Dehra Dun

manii Rao

Meinertomyia manii, Rao, *Indian J. Ent.*, 11 (2): 110 (1951)[1].
[1]Agra

11. **Haplusia** Karsch

Haplusia, Karsch, *Revision der Gallnucken*, W. p. 16 (1877) [Genotype: *Haplusia plumipes* Karsch]. Rubsaamen, *Berl. Ent., Zeitschr.*, 37 : 328, 368-369 (1892). Kieffer, *W. Ent. Z.*, 15 : 91 (1891); *Ann. Soc. Ent. France*, 69: 448 (1900). Felt, *J. N. Y. ent. Soc.*, 19 : 37 (1911); *Bull. N. Y. St. Mus.*, 147 : 84 (1911). Kieffer, *Gen. Ins.*, 152: 114 (1913). Felt, *Bull. N. Y. St. Mus.*, 165:210 (1913); *ibid.*, 257:139 (1925); *Lingnan Sci. J.*, 7: 427 (1929). Mani, *Indian J. Ent.*, 7 (1&2): 194 (1946).

brevipalpia Rao

Haplusia brevipalpia, Rao, *Indian J. Ent.*, 11 (2) : 113 (1951)[1].
[1]Agra

longipalpia Rao

Haplusia longipalpia, Rao, *Indian J. Ent.*, 11 (2) : 112 (1951)[1].
[1]Agra

12. **Neohaplusia** Rao

Neohaplusia, Rao, *Indian J. Ent.* 11(2) : 114 (1951) [Genotype: *Neohaplusia neohaplusia* Rao].

agraensis Rao

Neohaplusia agraensis, Rao, *Indian J. Ent.*, 11 (2) : 116 (1951)[1].
[1]Agra

neohaplusia Rao

Neohaplusia neohaplusia, Rao, *Indian J. Ent.*, 11 (2) : 114 (1951)[1].
[1]Agra

13. **Haplusiella Rao**

Haplusiella, Rao, *Proc. R. ent. Soc. London*, (B) 21 (3-4): 49-50 (1952). [Genotype: *Haplusiella pectiniclava* Rao]

pectiniclava Rao

Haplusiella pectiniclava, Rao, *Proc. R. ent. Soc. London*, (B) 21 (3-4):49 (1952)[1].
[1]Agra

indica Rao

Haplusiella indica, RAO, *Rec. Indian Mus.*, 50 : 309 1952)[1]. [1]Agra

Subfamily ITONIDIDINAE Hendel

Cecidomyinae, RONDANI, *Atti. Soc. Sc. Nat. Milano*, 5 (2): 1-9 (1861). KIEFFER, *Gen. Ins.*, 152 : 15 (1913). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 1 (1928).

Itonididinae, HENDEL, *Verh. k. k. Zool.-bot. Ges. Wien*, 58:49 (1908). FELT, *Bull. N. Y. St. Mus.*, 257:139 (1925); *Lingnan Sci. J.*, 7: 428 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 377 (1934); *Indian J. Ent.*, 7 (1&2): 190 (1946).

Tribe PORRICONDYLINI

14. **Clinophaena** Kieffer

Clinophaena, KIEFFER, *Trans. Linn. Soc. London.*, (2) *Zool.*, 14:328 (1911) [Genotype: *Clinophaena mahensis* Kieffer; *Gen. Ins.*, 152: 268 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 140 (1925); *Lingnan Sci. J.*, 7: 429 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 385 (1934); *Indian J. Ent.*, 7 (1&2): 196 (1946).

Holoneurus (partim), KIEFFER, *Trans. Linn. Soc. London.*, (2) Zool., 14 : 328 (1911).

indica Mani

Clinophaena indica, MANI, *Rec. Indian Mus.*, 36 (4) : 385 (1934)[1]. [1]Kurseong

longiptera Nayar

Clinophaena longiptera, NAYAR, *Proc. R. ent. Soc.*, (B)18 (5-6) : 82 (1949)[1]. [1]Calcutta

15. **Colpodia** Winnertz

Colpodia, WINNERTZ, *Linn. ent. Stett.*, 8 : 188 (1853) [Genotype: *Colpodia augustipennis* Winnertz]. FELT, *Bull. N. Y. St. Mus.*, 124 : 416 (1908). KIEFFER, *Gen. Ins.*, 152 : 268 (1913). WILLISTON, *N. Amer. Dipt.*, 38 : 10 (1908). BRUNETTI, *Rec. Indian Mus.*, 17:17 (1920). FELT, *Bull. N. Y. St. Mus.*, 257: 140 (1925). SENIOR--WHITE, *Cat. Indian Ins.*, 15 : 17 (1928). FELT, *Lingnan Sci. J.*, 7 : 429 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 385 (1934); *ibid.*, 37 (4): 430 (1935); *Indian J. Ent.*, 7 (1&2) : 196 (1946).

fletcheri Felt

Colpodia fletcheri, FELT, *Can. Ent.*, 48 : 29-34, 400-405 (1916)[1]. BRUNETTI, *Rec. Indian Mus.*, 17:16 [1,2,3],Pusa

1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15:17 (1928). FELT, *Lingnan Sci. J.*, 7 : 460 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 385 (1934); *ibid.*,37 (4) : 430 (1935)[3].

dhakae Mani

Colpodia dhakae, MANI, *Rec. Indian Mus.*, 37 (4): 430 (1935)[1] [ex gall No. on *Butea frondosa Roxb*]. [1]Dehra Dun

16. **Winnertzia** Rondani

Cecidomyia (partim), BOUCHE, *Naturgesch, d. Insekten*, 1:27 (1834).

Asynapta (partim), WINNERTZ, *Linn. Ent. Stett.*, 8 : 305 (1853).

Winnertzia, RONDANI, *Atti. Soc. Ital. Sci. Nat. Milano*, 2 : 287 (1860) [Genotype: *Winnertzia lugibris*]; FELT, *Bull. N. Y. St. Mus.*, 124 : 415, 421-422 (1908). KIEFFER, *Gen. Ins.*, 152 : 281 (1913); *Marcellia*, 2 :235 (1913). FELT, *Bull. N. Y. St. Mus.*, 180: 130 (1915); *ibid.*, 257:139 (1925); *Lingnan Sci. J.*, 7 : 428 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 384 (1934); *Indian J. Ent.*, 7 (1&2) : 196 (1946).

Clinorhiza, KIEFFER, *Ann. Soc. Ent. France*, 63 : 340 (non 313) (1864).

Winnertziola, KIEFFER, *Marcellia*, 2 : 235 (1913); *Gen. Ins.*, 152 : 283 (1913). FELT, *Bull. N. Y. St. Mus.*, 180 : 130 (1915).

burmitica (Cockerell)

Winnertziola burmitica, COCKERELL, *Pysche*, 24: 200 (1917).

Winnertzia burmitica, MANI, *Rec. Indian Mus.*, 36 (4); 334 (1934) [Fossil species from Burmese Amber].

17. **Bainidiplosis** Mani

Bainidiplosis, MANI, *Rec. Indian Mus.*, 37 (4) : 427 (1935) [Genotype: *Bainidiplosis championi* Mani]; *Indian J. Ent.*, 7 (1&2) : 196 (1946).

championi Mani

Bainidiplosis championi, MANI, *Rec. Indian Mus.*, 37 (4): 428 (1935)[1] [ex gall on *Quercus dilatata*]. [1]Chakrtta

18. **Vanchidiplosis** Nayar

Vanchidiplosis, NAYAR, *Proc. R. ent. Soc., London*, (B) 18 (5-6) : 81 (1949) [Genotype : *Vanchidiplosis vanchii* Nayar].

agreansis Rao

Vanchidiplosis agraensis, RAO, *Rec. Indian Mus.*, 48 : 31 (1950)[1]. [1]Agra

vanchii Nayar

Vanchidiplosis vanchii, NAYAR, *Proc. R. ent. Soc., London*, ( ),18 (5-6):82 (1949)[1] . [1]Trivandrum

19. **Rübsaamenia** Kieffer

Cecidomyza, ZETTERSTEDT, *Dipt. Scandinav.* 8 : 3680 (1850).
Asynapta, WINNERTZ, *Linn. Ent., Stett.* 8 : 303 (1853).
Rübsaamenia, KIEFFER, *Ann. Soc. Ent. France*, 63 : 333 (1894) [Genotype : *Rübsaamenia pectoralis* (Winnertz)]; *Gen. Ins.*, 152 : 278 (1913). FELT, *Buul. N. Y. St. Mus.*, 257 : 140 (1925); *Lingnan Sci. J.*, 7 : 429 (1929). MANI, *Indian J. Ent.*, 7 (1&2) : 197 (1946).

artocarpi Nayar

Rubsaamenia artocarpi, NAYAR, *Proc. R. ent. Soc., London* (B) 18 (5-6):83 (1949)[1] [ex decaying fruits of *Artocarpus integrifolia L.*]. [1]Trivandrum

20. **Pruthidiplosis** Mani

Pruthidiplosis, MANI, *Rec. Indian Mus.*, 36 (4) : 389 (1934) [Genotype: *Pruthidiplosis mimusopsicola Mani*]; *Indian J. Ent.*, 7 (1&2) : 198 (1946).

mimusopsicola Mani

Pruthidiplosis mimusopsicola, MANI, *Rec. Indian Mus.*, 36 (4) : 390 (1934)[1]. figs 4 & 5 [ex gall No. 235 on flowers of *Mimusops hexandra* Roxb.]; *J. R. Asiatic Soc. Bengal*, 14 : 90, 144 (1948).[2] [1,2]Tanjore

21. **Lopesiella** Tavares

Lopesiella, TAVARES, *Broteria*, 7 : 145 (1908) [Genotype: *Loepsiella combreti* Taveres]. KIEFFER, *Gen. Ins.*, 152:252 (1913). FELT, *Bull. N. Y. St. Mus.*, 257: 142 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15: 16 (1928). FELT, *Lingnan Sci. J.*, 7: 430 (1929). MANI, *Rec. Indian Mus.*,36 (4) : 388 (1934); *Indian J. Ent.*, 7 (1&2) : 199 (1946).

polliniae Felt

Lopesiella pollinia, FELT, *Mem. Dept. Agric. India, ent. Ser.*, 10; 2-3 (1927)[1] [ex gall No. on *Eulalia tristachya* O. Ktz. (*Pollinia argentea*)]. SENIOR-WHITE, *Cat. Indian Ins.*, 15:17 (1928)[2]. FELT, *Lingnan Sci.* [1,2,3,4]Taliparamba

J., 7 : 460 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 389 (1934)[3]; *J. R. Asiatic Soc.* Bengal, 14 : 153 (1948)[4].

22. **Camptomyia** Kieffer

Cecidomyia (partim), DUFOUR, *Ann. Soc. Nat.*, (2) 16 : 261 (1841).

Eupidosis (partim), Löw, *Linn. Ent.*, *Stett.*, 5 : 377 (1851).

Camptomyia, KIEFFER, *Ann. Soc. Ent. France*, 63 : 323 (1894); *Gen. Ins.*, 152 : 277 (1913). FELT, *Bull. N. Y. St. Mus.*, 180: 179 (1915); *ibid.*, 257 : 142 (1925). SENIOR-WHITE, 15 : 18 (1928). FELT, *Lingnan Sci. J.*, 7 : 430 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 378 (1934); *Indian J. Ent.*, 7 (1&2) : 198 (1946).

artocarpi Nayar

Camptomyia artocarpi, NAYAR, *Proc. R. ent. Soc.*, London, (B)18 (5-6) : 83 (1949)[1] [ex decaying fruit *Artocarpus integrifolia L.*].

[1]Trivandrum

hibisci Felt

Camptomyia hibisci, FELT, *Mem. Dept. Agric.*, *Ent. Ser.*, 9 : 241 (1926)[1] [ex rotting stems of *Hibuscus sp.*]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 18 (1928)[2]. FELT, *Lingnan Sci. J.*, 7: 460 (1929). MANI, *Rec. Indian Mus.*, 36 (4); 388 (1934)[3].

[1,2,3]Coimbatore

morindae Felt

Camptomyia morindae, FELT, *Mem. Dept. Agric. Ent. Ser.*, 9 : 241 (1926)[1] [ex gall on *Morinda tinctoria* Roxb]. SENIOR-WHITE, *Cat. Indian Ins.*, 15: 18 (1928)[2]. FELT, *Lingnan Sci. J.*, 7 : 460 (1929)[3]. MANI, *Rec. Indian Mus.*, 36 (4) : 388 (1934)[4].

[1,2,3]Coimbatore
[4]Tanjore

ricini Felt

Camptomyia ricini, FELT, *Mem. Dept. Agric. India*, Ent. *Ser*,. 7 : 23 (1921)[1] [ex decaying shoots of *Ricinus communis* Linn.]. *Senior-White*, *Cat. Indian Ins.*, 15 : 18 (1928)[2]. FELT, *Lingnan Sci. J.*, 7 : 460 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 387 (1934)[3] [ex decaying capsules of *Ricinus communis* Linn].

[1,2]Coimbatore
[3]Tanjore

23. **Misocosmus** Kieffer

Epidosis (partim), KIEFFER, *Spol. Zeyl.*, 8 : 29 (1912).

Misocosmus, KIEFFER, *Bull. Nat. Hist. Metz.*, 28 : 55 (1913) [Genotype; *Misocosmus ceylanicus* Kieffer]; *Gen. Ins.*, 152 : 276 (1913). BRUNETTI, *Rec. Indian*

Mus., 17 : 17 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 141 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15:18 (1928). FELT, *Lingnan Sci. J.*, 7: 430 (1929). MANI, *Rec. Indian Mus.*, 36 (4):386 (1934); *Indian J. Ent.*, 7 (1&2):198 (1946).

ceylanicus Kieffer

Epidosisus ceylanicus, KIEFFER, *Spol. Zeyl.*, 8 : 29 (1912)[1]. *Misocosmus ceylanicus*, KIEFFER, *Gen. Ins.*, 152 : 276 (1913)[2]. BRUNETTI, *Rec. Indian Mus.*, 17 : 17 (1920)[3]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 18 (1928)[4]. FELT, *Lingnan Sci.*, *J.*, 7 : 460 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 386 (1934)[5]. — [1,2,3,4,5]Peradeniya: Ceylon

24. **Dicroneurus** Kieffer

Epidosis (partim), KIEFFER, *Ann. Soc. Ent. France*, 63 : 320 (1894).

Dicroneurus, KIEFFER, *Ent. Nachr. Berlin*, 21:122 (1895) [Genotype; *Dicroneurus lineatus* Kieffer]; *Gen. Ins.*, 152 : 270 (1913). BRUNETTI, *Rec, Indian Mus.*, 17 : 16 (1920). FELT, *Bull. N. Y. St. Mus.*, 257: 141 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 18 (1928). FELT, *Lingnan Sci. J.*, 7 : 430 (1929) MANI, *Rec. Indian Mus.*, 36 (4) : 386 (1934); *Indian J. Ent.*, 7 (1&2): 198 (1946).

indicus Kieffer

Epidosis indicus, KIEFFER, *Rec. Indian Mus.*, 9 : 200(1913)[1]. *Dicroneurus indicus*, KIEFFER, *Gen. Ins.*, 152: 270 (1913).[2] BRUNETTI, *Rec. Indian Mus.*, 17 : 16 (1920).[3] SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 18 (1928)[4]. FELT, *Lingnan Sci. J.*, 7 : 460 (1929). MANI, *Rec. Indian Mus.*, 36 (4):387 (1934). — [1,3,4]Kalighat [2,4]E. Indies

Tribe LASIOPTERINI

25. **Stefaniola** Kieffer

Stefaniella (partim), TAVARES, *Broteria*, 3 : 293 (1904).

Stefaniola, KIEFFER, *Bull. Soc. Hist. Nat. Metz.*, 28 : 45 (1913) [Genotype: *Stefaniola salsolae* (Tavares)]; *Gen. Ins.*, 152 : 27 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 143 (1925). MANI, *Rec. Indian Mus.*, 36 (4): 401 (1934); *Indian J. Ent.*, 7 (1&2): 200 (1946).

bengalensis Mani

Stefaniola bengulensis, MANI, *Rec. Indian Mus.*, 36 (4): 401 (1934)[1]. — [1]Bengal

26. **Stefaniella** Kieffer

Stefaniella, KIEFFER, *Syn. des Cecidomyies d'Europe et d'Algerie*, p. 55 (1898) [Genotype: *Stefaniella atriplicis Kieffer*]; *Gen. Ins.*, 152 : 28 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 143 (1925). MANI, *Indian Ent., J.* 7 (1&2): 200 (1946).

falcaria Felt

Stefaniella falcaria, FELT, *Treubia*, 1 : 141 (1921)[1] [ex gall on leaf of *Avicenia officinalis L.*]; *Lingnan Sci. J.*, 7 : 461 (1929).[2] — [1,2]Java

orientalis Felt

Stefaniella orientalis, FELT, *Treubia*, 1 : 142 (1921)[1] [ex gall on petiole of *Lepidagathis javanica* Bl.]; *Lingnan Sci. J.*, 7: 461 (1929)[2]. — [1,2]Java

27. **Neolasioptera** Felt

Cecidomyia (partim), FELT, *Bull. N. Y. St. Mus.*, 104 : 131 (1906).

Lasioptera (partim), BEUTENMULLER, *Bull. Amer. Mus. Nat. His.*, 23 : 298 (1907).

Choristoneura (partim), FELT, *Rep.* 22 *N. Y. St. Mus.*, 110; 155 (1907).

Neolasioptera, FELT, *Bull. N. Y. St. Mus.*, 124:330 (1908). Kieffer, *Gen. Ins.*, 152: 22 (1913). FELT, *Bull. N. Y. St. Mus.*, 198 : 171 (1918); *ibid.*, 257:143 (1925). MANI, *Rec. Indian Mus.*, 36 (4): 396 (1934); *Indian J. Ent.*, 7 (1&2): 200 (1946).

crataevae Mani

Neolasioptera crataevae, MANI, *Rec. Indian Mus.*, 36 (4): 399 (1934)[1] [ex gall No. 172 on flower buds of *Cataevae religiosa* Förster]; *J. R. Asiatic Soc. Bengal*, (Sci.) 14 : 91, 133 (1948)[2]. — [1,2]Tanjore

cephalandrae Mani

Neolasioptera cephalandrae, MANI, *Rec. Indian Mus.*, 36 (4) : 397 (1934)[1] [ex gall No. 219 on stem of *Coccinia* (=*Cephalandra*) *indica* Naud.]; *ibid.*, 38 (2): 193 (1936)[2]. *ibid.*, 40 (4): 331 (1938)[3]; *Indian J. Ent.*, 5 : 151 (1943)[4] ; *J. R. Asiatic. Soc. Bengal.*, 14 : 91, 141 (1948)[5].

[1,5]Tanjore, Coimbatore, Erode, Vellore, Madras, Calcutta,
[2]Coimbatore
[3]Pusa, Delhi
[4]Udaipur

sp. Mani

Neolasioptera Sp., MANI, *Agra Univ. J. Res.* (Sci.), 3 (1): 16, figs. 1-5, (1954)[1], [ex gall No. 479 on leaf of *Machilus odoratissima* Nees]. — [1]Dharamsala: Dholadhar Himalayas

variipalpis Mani

Neolasiootera variipalpis, Mani, *Rec. Indian Mus.*, 39 (3) : 282 (1937)[1].

[1]Calcutta

28. **Lasioptera** Meigen

Tipula (partim), Schrank, *Enum. Insect. Austr.*, p. 435 (1781).

Cecidomyia (partim), Meigen, *Klassif. Dipt.*, 1 : 40 (1804).

Lasioptera, Meigen, *Syst. Beschr. Europe, Zweifl. Insket.*, 1 : 88 (1818) [Genotype: *Lasioptera albipennis* Meigen]. Winnertz, *Linn. Ent.*, 8 : 191 (1853). Osten Sacken, *Mon. N. Amer. Dipt.*, 1 : 175 (1862). Schiner, *Fauna Austriaca die Fliegen*, (2) 28-29: 406 (1864). Felt, *Bull. N. Y. St. Mus.*, 124: 323-327 (1908). Kieffer, *Gen. Ins.*, 152 : 30 (1913). Felt, *Bull. N. Y. St. Mus.*, 198 : 107 (1918). Brunetti, *Rec. Indian Mus.*, 17 : 8 (1920). Felt, *Bull. N. Y. St. Mus.*, 257 : 142 (1925). Senior-White, *Cat. Indian Ins.*, 15 : 1 (1928). Felt, *Lingnan Sci. J.*, 7 : 431 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 393 (1934); *Indian J. Ent.*, 7 (1&2): 200 (1946).

Diomyza, Meigen, *Syst. Beschr. Europe Zweifl. Insekt.*, 1 : 89 (1818).

eriochloa Felt

Lasioptera eriochloa, Felt, *Mem. Dept. Agric. India, Ent. Ser.*, 9 : 244 (1926)[1] [ex gall on *Eriochloa polystachya* H. B. K.]. Senior-White, *Cat. Indian Ins.*, 15:1 (1928)[2]. Felt, *Lingnan Sci. J.*, 7: 461 (1929). Mani, *Rec. Indian Mus.*, 36 (4): 394 (1934)[3]; *J. R. Asiatic Soc. Bengal*, 14 : 91, 153 (1948)[4].

[1,2,3,4]Calcutta

javanica Kieffer & Leewen

Lasioptera javanica, Kieffer & Leeuwen, *Marcellia*, 8 : 123 (1909). Felt, *Treubia*, 1 : 142 (1921)[1] [ex gall on stem of *Melothria* sp.]; *Lingnan Sci. J.*, 7:461 (1929)[2].

[1,2]Java

manilensis Felt

Lasioptera manilensis, Felt, *Philipp. J. Sci.*, 13 : 228 (1918)[1] [ex gall on leaf of *Leea manillensis* Walp.]. Uichanco, *Philipp. J. Sci.*, 14 : 539 (1919). Felt, *Treubia*, 1 : 143 (1921)[2] [ex gall on leaf of *Leea sambucina* Wlld.]; *Mem. Dept. Agric. India, Ent. Ser.*, 9:241-245 (1926); *Lingnan Sci. J.*, 7: 461 (1929).

[1]Philippines
[2]Java

falcata Felt

Lasiopterafalcata, FELT, *Philipp. J. Sci.*, 14 : 288 (1919)[1] [ex gall on stem of a wild cucurbit]. RAMAKRISHNA, *Rep. Proc. III ent. Meet. pusa*, 1 : 324 (1919). FELT, *Lingnan Sci. J.*, 7 : 461 (1929)[2] [ex gall No. 226 on stem of *Momordica charantia* Linn.]. MANI, *Rec. Indian Mus.*, 36 (4) : 394 (1934)[3]; *Indian J. Ent.*, 5 : 151 (1943)[4] [ex gall No. 227 on stem of *Momordica dioica* Roxb.]; *J. R. Asiatic Soc. Bengal*, 14 : 91, 142 (948)[5].

[1,2]Philippines
[3]South India
[4]Udaipur
[5]Java, Celebes

fluitans Felt

Lasioptera fluitans, FELT, *Ent. News.*, 28 : 73 (1917)[1] [ex gall on *Panicum fluitans* Retz.]; *Pusa Bull.* 89 : 42 (1918) [redescription]. BRUNETTI, *Rec. Indian Mus.*, 17 : 9 (1920)[2]. FELT, *Mem. Dept. Agric, Ent. Ser.*, 7: 17 (1921). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 2 (1928).

bryoniae Schiner

Lasioptera bryoniae, SCHINER, *Novara Reise, Dipt.*, p. 5 (1868)[1]. KIEFFER, *Gen. Ins.*, 152 : 31 (1913)[2]. BRUNETTI, *Rec. Indian Mus.*, 17 : 9 (1920)[3] . SENIOR WHITE, *Cat. Indian Ins.*, 15: 1 (1928)[4]. FELT, *Lingnan Sci. J.* 7 : 461 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 394 (1934)[5] [ex gall on stem of *Bryonia sp.*]; *J. R. Asiatic Soc. Bengal*, 14: 91, 141 (1948)[6] [ex gall on No. 218 on stem of *Bryonia laciniosa* Linn.]

[1,2,3,4]Madras
[5,6]Vellore

paniculi Felt

Lasioptera paniculi, FELT, *Philipp. J. Sci.*, 17 : 232 (1920)[1]; *Lingnan Sci. J.*, 7 : 461 (1929)[2] [ex gall on the panicles of *Panicum carinatum* Presl.]. MANI, *Rec. Indian Mus.*, 36 (4) : 349 (1934)[3] [ex gall on ear heads of *Panicum prostratum* Lamarck]; *J. R. Asiatic Soc. Bengal*, 14 : 91, 153 (1948)[4].

[1,2,4]Madras
[3]Coimbatore

indica Rao

Lasioptera indica, RAO, *Proc. R. ent. Soc., London*, (B) 21 (3-4); 50-51 (1952)[1] .

asystasiae Nayar

Lasioptera asystasiae, KIEFEER, *Indian J. Ent.*, 4 (1-2): 71 (1944)[1]. (ex galls on stem of *Asystasia violacca* Daz.).

[1]Pampadampara

longispatha Kieffer

Lasioptera longispatha, KIEFFER, *Marcellia*, 7 : 157 (1908)[1] (ex galls of *Camellia, drupifera lowv*); *Gen. Ins.*, 152 : 32 (1913)[2] (larvae only). BRUNETTI,

[1,2]Kurseong

Rec. Indian Mus., 17 : 9 (1920). MANI, *Rec. Indian Mus.*, 36 : 395 (1934). — [1,2]Kurseong

trilobata Kieffer

Lasioptera trilobata, KIEFFER *Marceilia*, 7 : 157 (1908)[1] (ex galls of *Schima Walhi chosky*); *Gen. Ins*; 152 : 53 (1913)[2] (larval only). MANI, *Rec. Indian Mus.*, 36 : 395 (1934)[3]. — [1,2,3]Kurseong

textor Kieffer

Lasioptera ? *textor*, KIEFFER, *Ann. Soc. Scient Bruxelles*, 29 : 155 (1905)[1] (ex galls of *Polygonum molle D. Don.*). BRUNETTI, *Rec. Indian Mus.*, 17 : 9 (1920) SENIOR-WHITE, *Cat Indian Ins.*, 15 : 2 (1928)[2]. MANI, *Rec. Indian Mus.*, 36 : 395 (1934). — [1,2]Bengal

29. **Prolasioptera** Kieffer

Cecidomyis (partim), VALLET, *Mem Acad. Sci. Rijon*, p. 113 (1828-29).

Lasioptera (partim), KIEFFER, *Ann. Soc. Sci* Bruxelles, 28 : 338 (1904)

Prolasioptera, KIEFFER, *Bull. Soc. Nat. Hist. Metz.*, 28 : 47 (1913) [Genotype: *Prolasioptera niveocinecta* Kieffer]; *Gen. Ins.*, 152 : 33 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 143 (1925); *Lingnan Sci. J.*, 7: 461 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 395 (1934); *Indian J. Ent.*, 7 (1&2): 201 (1946).

javanica (Kieffer & Leeuwen)

Lasioptera javanica, KIEFFER & LEEUWEN-REJNVAAN, *Marcellia*, 8:123 (1909)[1].

Prolasioptera javanica, KIEFFER, *Gen. Ins.*, 152 : 33 (1913). FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 9 : 241-245 (1926)[2]; *Lingnan Sci. J.*, 7 : 461 (1929)[3]. MANI, *Rec. Indian Mus.*, 37 (4): 450-451 (1935) [Galls only]; *Bull. ent. Res.*, 38 (3) : 439 (1947) [ex gall No. 222 on *Melothria heterophylla* Cogn. and gall No. 225 on *Melothria parpusiella* Cogn.]; *J. R. Asiatic Soc. Bengal*, 14 : 91 (1948)[5].

[1]Java
[2]India
[3]E. Indies
[4]S. India
[5]Tanjore, Celebes

annandalei Mani

Prolasioptera annandalei, MANI, *Rec. Indian Mus.*, 36 (4); 395 (1934)[1]. — [1]Chilka Lake

aeschinanthus-perottetti Mani

Prolasioptera aeschinanthus-perottetti, MANI, *Indian J. Ent.*, 5:151 (1943)[1] [ex gall on No. 306 on stem of *Aeshynanthus perottetti* A. Dc.] NAYAR, *Proc. Indian Acad. Sci.*, 26 (6) 234 (1947)[2]. MANI, *J. R. Asiatic Soc. Bengal*, 14:91, 147 (1948)[3]. — [1,2,3]Pampadapara : Travancore.

30. **Neoprotoplonyx** Rao

Neoprotoplonyx, Rao, *Rec. Indian Mus.*, 48 (3& 4): 33 (1950) [Genotype: *Neoprotoplonyx indica* Rao].

indica Rao

Neoprotoplonyx indica, Rao, *Rec. Indian Mus.*, 48 (3 & 4) : 33 (1950)[1]. — [1]Agra

Tribe Dasyneurini

31. **Scheueria** Kieffer

Scheueria, Kieffer, *Centralbl. f. Bakteriol. Parasitenkunde,* etc., *Abt.* (2) 23 : 120 (1909) [Genotype: *Scheueria agglomerata* Kieffer]; *Gen. Ins.*, 152 : 38 (1913). Felt, *Bull. N. Y. St. Mus.*, 257 : 147 (1925); *Lingnan Sci. J.*, 7 : 435 (1929). Mani, *Indian J. Ent.*, 7 (1& 2): 202 (1946).

schefflerae Felt

Scheueria schefflerae, Felt, *Philipp. J. Sci.*, 17: 231-34 (1920)[1] [ex gall on leaf of *Schefflera sp*]; *Lingnan Sci. J.*, 7: 461 (1929). — [1]Philippines

32. **Ctenodactylomyia** Felt

Ctenodactylomyia, Felt, *Proc. U. S. Nat. Mus.*, 48 : 199 (1915) [Genotype; *Ctenodactylomyia watsoni* Felt]; *Bull. N. Y. St. Mus.*, 257 : 147 (1925); *Lingnan Sci. J.*, 7 : 435 (1929). Mani, *Indian J. Ent.*, 7 (1 & 2) : 201 (1946).

antidesmae Felt

Ctenodactylomyia antidesmae, Felt, *Philipp. J., Sci.*, 14 : 287-294 (1919)[1]. [ex gall on leaf of *Anteidesma leptocladum* Tub].; *Mem. Dept. Agric. India, Ent. Ser.*, 9 : 241-245 (1962)[2] ; *Lingnan Sci. J.*, 7 : 461 (1929). — [1]Philippines [2]East Indies

33. **Alassomyia** Felt

Allomyia Felt, *J. Econ. Ent.*, 11 : 380 (1918) (nec Banks) (Pre occ. 1916); *Bull. N. Y. St. Mus.*, 257 : 147 (1925).

Alassomyia, Felt, *Bull. N. Y. St. Mus.*, 257 : 147; (1925) [Genotype: *Alassomyia juniperi* Felt]; *Lingnan Sci. J.*, 7 : 485 (1929) (misspelt as *Allasomyia*,) Mani, *Indian J. Ent.*, 7 (1 & 2) : 201 (1946) (misspelt as *Allasomyia*)

tenuispatha (Kieffer)

Oligotrophus tenuispatha, KIEFFER, *Marcellia*, 7 : 150 (1908)[1] * [ex gall on leaf of *Mangifera indica* Linn.] ; *Gen. Ins.*, 152 : 50 (1913)[2] . BRUNETTI, *Rec. Indian Mus.*, 17 : 9 (1920)[3]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 3 (1928). FELT, *Lingnan Sci. J.*, 7 : 461 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 405 (1934).

[1]Ranchi
[2,3]East Indies

Alassomyia tenuispatha, NAYAR, *Indian J. Ent.*, 6 (1 & 2): 71 (1944)[1]. [ex gall No. 190 on leaf of *Mangifera indica* Linn.]. (misspelled as *Allasomyia tenuisptha*). MANI, *J. R. Asiatic Soc. Bengal*, 14 : 91,136 (1948) [ex gall No. 190 on leaf of *Mangifera indica* Linn.]. Mani, *Agra Univ. J. Res.*, (*Sci.*), 1 : 48 (1952).

[1]Cape Comerin

34. **Calopedila** Kieffer

Rhopalomyia (partim), KIEFFER, *Revista Chilena Hist.* Nat., 7 : 226 (1903).

Calopedila, KIEFFER, *Bull. Soc. Hist. Nat. Metz.*, 28 : 48 (1912) [Genotype : *Calopedila herbsti* Kieffer]; *Gen. Ins.*, 152:55 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 146 (1925); *Lingnan Sci. J.*, 7 : 435 (1929). MANI, *Indian J. Ent.*, 7 (1&2); 201 (1946).

polyalthiae Felt

Calopedila polyalthiae, FELT, *Treubia*, 9 : 385-389 (1927)[1] [ex gall on fruit of *Polyalthia subcordata* Bl.]; *Lingnan Sci. J.*, 7 : 461 (1929).

[1]East Indies

35. **Harpomyia** Felt

Harpomyia, FELT, *Can. Ent.*, 48 : 40 (1916) [Genotype: *Harpomyia indica* FELT]. BRUNETTI, *Rec. Indian Mus.*, 17 : 10 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 146 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 3 (1928). FELT, *Lingnan Sci. J.*, 7 : 434 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 404 (1934); *Indian J. Ent.*, 7 (1&2); 203 (1946).

indica Felt

Harpomyia indica, FELT, *Can. Ent.*, 48 : 401 (1916)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 10 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 3 (1928). FELT, *Lingnan Sci. J.*, 7 : 461 (1929). MANI, *Rec. Indian Mus.*, 36 (4); 404 (1934).

[1,2]Pusa

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*Described from larvae only.

36. **Dasyneura** Rondani

Dasineura, RONDANI, *sopra alcuni nuovi generi d' Insetti Ditteri, Parma*, p. 17 (1840).

Dasyneura, RONDANI. *Nuov. Ann. Soc. Nat. Bologna*, (2)6 : 12 (1840) [Genotype: *Dasyneura obscura* Rondani]. FELT, *Bull. N. Y. St. Mus.*, 124 : 340 (1908). KIEFFER, *Gen. Ins.*, 152 : 86 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 10 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 145 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 3 (1928). FELT, *Lingnan Sci. J.*, 7 : 434 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 403 (1934); *Indian J. Ent.*, 7 (1 & 2) : 203 (1946).

gossypii Felt

Contarinia sp., FLETCHER, *South Indian Ins.*, p. 363 (1914)[1].
[1]Coimbatore

Dasyneura gossypii FELT, *Can. Ent.*, 48 : 29 (1916)[2]. BRUNETTI, *Rec. Indian Mus.*, 17 : 10, (1920)[3]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 3 (1928). FELT, *Lingnan Sci. J.*, 7 : 461 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 403 (1934).
[2,3,4]South India
2,3,4

elatostemma Felt

Dasyneura elatostemma, FELT, *Treubia*, 1 : 140 (1921)[1]. [ex gall on petiole of *Elatostemma* sp.]; DOCTORS VAN LEEUWEN, *Treubia*, 1 : 153 (1921) (note on the gall). FELT, *Lingnan Sci. J.*, 7 : 461 (1929)[2].
[1,2]Java

mangiferae Felt

Dasyneura mangiferae, FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 10 : 1 (1927)[1]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 3 (1928)[2]. FELT, *Lingnan Sci. J.*, 7 : 461 (1929) [ex mango flowers]. MANI, *Rec. Indian Mus.*, 36 (4) : 404 (1934); *Indian J. Ent.*, 5 : 152 (1943)[3] [ex gall No. 104 on flowers of *Mangifera indica* Linn.] Mani, *Agra Univ. J. Res.* (Sci.) 1 : 47 (1952).
[1,2]Coimbatore

lini Barnes

Dasyneura lini, BARNES, *Ann. Mag. Nat. Hist.* 17 (10) : 273-274 (1936)[1]. [on pollen of flowers of *Linum usitatissimum* L.]. Pruthi & Bhatia, *Indian J. Agric. Sci.*, 7 (5); 797-808 (1937) [Biology].
[1]Pusa

tetrastigma Felt

Dasyneura tetrastigma, FELT, *Treubia*, 9 : 385 (1927)[1]. [ex gall on stem of *Tetrastigma pergamaceum* Planch.]; *Lingnan Sci. J.*, 7 : 461 (1929)[2].
[1]E. Indies

37. **Trichoperrisia** Kieffer

Trichoperrisia, KIEFFER, *Rec. Indian Mus.*, 9:199 (1913) [Genotype : *Trichoperrisia pipericola* Kieffer]; *Gen. Ins.*, 152 : 65 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 10 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 145 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 3 (1928). FELT, *Lingnan Sci. J.*, 7 : 483 (1929). MANI, *Rec.* 36 (4); 403 (1934); *Indian J. Ent.*, 7 (1&2) : 204 (1946).

pipericola Kieffer

Trichoperrisia pipericola, KIEFFER, *Rec. Indian Mus.*, 9 : 199 (1913)[1] ex gall No. 257 on leaf of *Piper nigrum* Linn.]; *Gen. Ins.*, 152 : 55 (1913)[2]. BRUNETTI, *Rec. Indian Mus.*, 17 : 10 (1920)[3]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 3 (1928)[4]. FELT, *Lingnan Sci. J.*, 7 : 461 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 403 (1934); *J. R. Asiatic Soc., Bengal*, 14 : 91, 149 (1948)[5].

[1,3,45],Ceylon
[2,4]E. Indies

38. **Rhabdophaga** Westwood

Cecidomyia (partim), DUFOUR, *Ann. Sci. Nat.* (2)16 : 262 (1841).

Dichelomyia (partim), RÜBSAAMEN, *Berl. Ent. Zeitschr.*, 37 : 346 (1892).

Bertieria, KIEFFER, *Bull. Soc. Ent. France*, p. 189 (1896).

Rhabdophaga, WESTWOOD, *Gard. Chron.*, p. 588 (1897). KIEFFER, *Gen. Ins.*, 152 : 69 (1913). FELT, *Bull. N. Y. St. Mus.*, 175 : 81 (1915); *Ibid.*, 257 : 144 (1925); *Lingnan Sci., J.*, 7 : 433 (1929). MANI, *Indian J. Ent.*, 7 (1&2); 204 (1946).

mangiferae Mani

Rhabdophaga mangiferae, MANI, *Rec. Indian Mus.*, 40 (4) : 331 (1938)[1]; *J. R. Asiatic Soc. Bengal*, 14 : 92, 137 (1948)[2] [ex gall No. 197 on shoots of *Mangifera indica* Linn.]; *Agra Univ. J. Res.* (Sci), 1 : 48 (1952)[3].

[1]Trichur
[2]Cochin
[3]Guntur

39. **Hallomyia** Kieffer

Hallomyia, KIEFFER, *Spol. Zeyl.*, 8 : 25 (1912) [Genotype: *Hallomyia iris* Kieffer]; *Gen. Ins.*, 152 : 106 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 11 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 144 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 6 (1928). FELT, *Lingnan Sci. J.*, 7 : 433 (1929). MANI, *Rec. Indian*

Mus., 36 (4): 402 (1934) ; *Indian J. Ent.*, 7 (1 &2): 204 (1946).

iris Kieffer

Hallomyia iris, KIEFFER, *Spol. Zeyl.*, 8 :25 (1922)[1]; *Gen. Ins.*, 152 : 106 (1913)[2]. BRUNETTI, *Rec. Indian Mus.*, 17 : 11 (1920)[3]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 6 (1928). FELT, *Lingnan Sci. J.*, 7 : 461 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 402 (1934)[4].

[1,3]Paradeniya
[2,4]Ceylon

cardamomi Nayar

Hallomyia cardamomi, NAYAR, *Proc. R. ent. Soc. London*, (B) 18 (5-6) : 84 (1949)[1] [ex gall on root of *Eletteria cardamomi* Maton].

[1]Travancore

40. **Chastomera** Skuse

Chastomera, SKUSE, *Proc. Linn. Soc. N. S. Wales*, (2) 3 : 112 (1888) [Genotype: *Chastomera balla* Skuse]. KIEFFER, *Gen Ins.*, 152:115 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : (1925). MANI, *Indian J. Ent.*, 7 (1&2); 204 (1946).

spiculosa Barnes

Chastomera spiculosa BARNES, *J. Fed. Malay St. Mus.*, 13:1-6 (1927)[1] FELT, *Lingnan Sci. J* 7 : 460 (1929). Tribe OLIGOTROPHINI.

[1]Malay

41. **Misospatha** Kieffer

Cecidomyia (partim), BOUCHE, *Naturg. Insekt.*, p. 27 (1834). AMBLARD, *Ann. Soc. Ent. France*, 25 : 169-172 (1856).

Hormomyia (partim), BERGENSTAMM P. Löw, *Verh. Zool.-Bot. Ges, Wien*, 26 : 65 (1876).

Dasyneura (partim), KARSCH, *Revision der Gallmücken*, p. 3 (1877).

Rhopalomyia (partim), RÜBSAAMEN, *Berlin Ent. Zeitschr*, 37: 370 (1892)

Asphondylia, COCKERELL *Can. Ent.*, 33:23 (1901).

Diplosis (partim), COCKERELL, *Can. Ent.*, 36 : 155 (1908).

Oligotrophus (Partim), KIEFFER, *Ann. Soc. Ent. France*, 81: 126 (1912).

Amblardiella, KIEFFER, *Marcellia*, 11 : 169 (1912); *Gen.* Ins., 152 : 84 (1913).

Misospatha, KIEFFER, *Bull. Soc. Hist. Nat. Metz.*, 28:48 (1913): [Genotype: *Misospatha globifex* (Kieffer & Jorgan)]. *Gen. Ins.*, 152:44 (1913) FELT, *Bull. N. Y. St. Mus.*, 257:150 (1925); *Lingnan Sci. J.*, 7: (1929). MANI, *Rec. Indian Mus.*, 37

(4): 432 (1935); *ibid.*, 50 (4): 332 (1938); *Indian J. Ent.*, 7 (1&2):205 (1946).

tamaricum (Kieffer)

Perrisia tamaricum, KIEFFER, *Bull. Soc. Hist. Nat. Metz.*, 26 : 30 (1909)[1] [ex galls on *Tamarix gallica*]; *Gen. Ins.*, 152 : 82 (1913). [1]Africa

Oligotrophus tamaricum, KIEFFER, *Ann. Soc. Ent. France*, 81 : 126 (1912)[2] [ex gall on *Tamarix gallica*]; *Gen. Ins.*, 152 : 50 (1913). [2]Egypt

Amblardiella tamaricum, KIEFFER, *Ann. Soc. Ent. France*, 81 : 126 (1912) [ex gall on *Tamarix gallica*]; *Gen. Ins.*, 152 : 84 (1913).

Misospatha tamaricis, MANI, *Rec. Indian Mus.*, 37 (4): 432 (1935)[3] [ex gall on *Tamarix dioica* Roxb.]. [3]Punjab

Misospatha tamaricum, MANI, *Rec. Indian Mus.*, 50: 332 (1938)[4]; *J. R. Asiatic Soc. Bengal*, 14 : 91, 133 (1948) [ex gall No. 174 on stem of *Tamarix gallica*]. [4]Dehra Dun [5]Pusa

42. **Panteliola** Kieffer

Cecidomyia (partim), OSTEN-SACKEN, *Trans. Amer, ent. Soc.*, 2 : 302 (1869).

Rhopalomyia (partim), RÜBSAAMEN, *Berlin Ent. Zeit.*, 38: 162 (1893). KIEFFER, *Ann. Soc. Sci. Bruxelles*, 29: 151 (1905). FELT, *Bull. N. Y. St. Mus.*, 257: 130 (1925); *Lingnan Sci. J.*, 7 : 438 (1929).

Panteliola, KIEFFER, *Bull. Soc. Nat. Hist. Metz.*, 28 : 49 (1913) [Genotype: *Panteliola hassi* (Kieffer)]; *Gen. Ins.*, 152 : 46 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 9 (1920). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 2 (1928). MANI, *Rec, Indian Mus.*, 36 (4) : 405 (1934); *Indian J. Ent.*, 7 (1&2) : 205 (1946).

hassi Kieffer

Rhopalomyia hassi, KIEFFER, *Ann. Soc. Sci. Bruxelles*, 29 : 151 (1905).

Panteliola hassi, KIEFFER, *Bull. Soc. Nat. Hist., Metz.*, 28 : 49 (1913); *Gen. Ins.*, 152 : 47 (1913)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 9 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 2 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 461 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 405 (1934)[4]; *J. R. Asiatic Soc. Bengal*, 14 : 91, 143 (1948)[5] [ex gall No. 231 on stem of *Artemisia* sp.]. [1,3]East Indies [2,3]Bengal [4]Tuticorin [5]Kurseong

43. **Luzonomyia** Felt

Luzonomyia, FELT, *Philipp. J. Sci.*, 13 : 281 (1918). [Genotype : *Luzonomyia symphoremae* Felt]; *Bull. N. Y. St. Mus.*, 257 : 149 (1925); *Lingnan Sci. J.*, 7 : 437 (1929). MANI, *Indian J. Ent.*, 7 (1 & 2) : 205 (1946).

symphoremae Felt

Luzonomyia symphoremae, FELT, *Philipp. J. Sci.*, 13:281 (1918)[1] [ex gall on leaf of *Symphorema luzonicum* F. Vill.]; *Lingnan Sci. J.*, 7 : 461 (1929). [1]Philippines

44. **Oligotrophus** Latreille

Tipula (partim), LINNE, *Syst. Nat. Ed.*, 10 : 588 (1758).

Oligotrophus, LATREILLE, *Hist. Nat. Crust. et. Insect.*, 14: 288 (1805) [Genotype : *Oligotrophus juniperinus* (Linne)]. RÜBSAAMEN, *Berlin, Ent. Z.*, 37:376 (1892). Felt, *Bull. N. Y. St. Mus.*, 124 : 368 (1908). KIEFFER, *Gen. Ins.*, 152 : 49 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 9 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 149 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 2 (1928). Felt, *Lingnan Sci. J.*, 7 : 437 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 404 (1934); *Indian J. Ent.*, 7 (1 & 2) : 205 (1946).

Hormomyia, (partim), WINNERTZ, *Stett. Ent. Zeit.*, 15 : 322 (1854).

Cecidomyia (partim), LATREILLE, *Gen. Crust. et. Insect.*, 4 : 253 (1809).

Lasioptera (partim), MEIGEN, *Syst. Beschr.*, 1:92 (1818).

indicus Kieffer

Oligotrophus indianus, KIEFFER, *Marcellia*, 7 : 152 (1908)[1] (Pre occ.). [1,2]E. Indies

Oligotrophus indicua, KIEFFER, *Marcellia*, 7 : 152 (1908); *nom. nov; Gen. Ins.*, 152:50 (1913)[2] BRUNETTI, *Rec, Indian Mus.*, 17:9 (1920). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 2 (1928). FELT, *Lingnan, Sci. J.*, 7 : 461 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 405 (1934); *J. R. Asiatic Soc., Bengal*, 14: 91, (1948)3 [ex gall No. 170 on stem of *Capparis viminea* Löw]

45. **Oligoxenomyia,** Felt,

Oligoxenomyia, FELT, *Treubia*, 9 : 386 (1927) [Genotype; *Dligoxenomyia radicis* Felt]; Lingnan Sci. J., 7 : 437

(1929). Mani, Indian J. Ent., 7 (1&2) : 206 (1946).

radicis Felt

Oligoxenomyia radicis, FELT, *Treubia*, 9 : 386 (1927)[1] ? [ex gall on the aerial root of *Freycinetia valida* Ridl.]; *Lingnan Sci. J.*, 7 : 461 (1929)[2].

[1,2]E. Indies

46. **Rhopalomyia** Rübsaamen

Cecidomyia (partim), HERMANN LÖW *Dipt. Beitr.*, 4 : 37, (1850).

Oligotrophus (partim) KARSH, 7 *Jahresber. Westf. Prov. Ver.*, p. 27 (1879).

Hormomyia (partim) LIEBEL, *Z. Naturwiss.*. 59 : 572 (1886).

Rhopalomyia (partim), RÜBSAAMEN, *Berl. Z. Ent.*, 37 : 370 (1892).

Rhopalomyia, KIEFFER, *Gen. Ins.*, 152 : 43, (1913). FELT, *N. Y. St. Mus., Bull.*, 257 : 150 (1925). MANI, *Indian J. Ent.*, 7 : 205 (1946). RUBSAAMEN & HEDICKE, *Die Cecidomyiden und ihre Cecidien*, p. 285, 288 (1938).

millefolii (H. Löw)

Cecidomyia millefolii, HERMANN LÖW, *Dipt. Beitr.*, 1 : 37 (1850).

Rhopalomyia millefolii, KIEFFER, *Gen. Ins.*, 152:44 (1913). HOUARD, *Les Zooceides des Plantes d' Afreque d'Asie et d'Oceanie*, p. 867 (1922). ROSS & HEDICKE, *Die Pflanzengallen Mittel- & Nordeuropas*, pp. 75-77 (1927). RÜBSAAMEN & HEDICKE, *Die Cecidomyiden und ihre Cecidien*. p. 289, pl. xxiii, fig. 8-11, (1938).[1] MANI, *Agra Univ. J. Res.* (Sci.) 3 (1) : 15, pl. viii (1954)[2] (ex gall No. 527 on leaf of *Achillea millefolium* Linn.)

[1]Europe & Africa
[2]Dalhouria : Himalayas

sp. Mani

Rhopalomyia sp., MANI, *Agra Univ. J. Res.* (Sci) 3 (1) : 15 (1954)[1] (ex gall No. 505 on *Achillea millefolium* Linn.).

[1]Dalhouria : Himalayas

Tribe ASPHONDYLINI

47. **Schizomyia** Kieffer

Cecidomyia (partim), WALSH & RILEY, *Amer. Ent., Philadalphia*, 2 : 106 (1869).

Epidosis (partim), F. LÖW, *Verh. Zool.-bot. Gez. Wien.*, 2,7 : 19 (1877).

Schizomyia, KIEFFER, *Ent. Nachr.*, 15:183 (1898) [Genotype: *Schizomyia gali* Kieffer]. FELT, *Bull. N. Y.*

St. Mus., 124 : 378 (1908). KIEFFER, *Gen. Ins.*, 152 : 88 (1913). FELT, *Bull. N. Y. St. Mus.*, 186 : 102 (1916). BRUNETTI, *Rec. Indian Mus.*, 17 : 10 (1920). FELT, *Bull. N. Y. St. Mus.*, 257: 151 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15:4 (1928). FELT, *Lingnan Sci. J.*, 7 : 439 (1929). MANI, *Rec. Indian Mus.*, 36 (4); 405 (1924); *Indian J. Ent.*, 7 (1&2) : 208 (1946).

assamensis Felt

Schizomyia assamensis, FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 3 (1920)[1] [ex gall No. 214 on *Rubus assamensis* Focke]. SENIOR-WHITE, *Cat. Indian Ins.*, 15:4 (1928)[2]. FELT, *Lingnan Sci. J.*, 7 : 462 (1929)[3]. MANI, *Rec. Indian Mus.*, 36 (4); 406 (1934); *J. R. Asiatic Soc. Bengal*, 14 : 92, 140 (1948)[4]. — [1,2,3,4]Shillong

maeruae Felt

Schizomyia maeruae, FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 9 : 243 (1926)[1] [ex gall No. 173 on *Maerua arenaria* HOOK.]. SENIOR-WHITE, *Cat. Indian Ins.*, 15:4 (1928)[2]. FELT, *Lingnan Sci. J.*, 7 : 462 (1929). MANI, *Rec. Indian Mus.*, 36 (4); 406 (1934)[3]; *J. R. Asiatic Soc. Bengal*, 14:92, 133 (1958)[4]. — [1,2,3,4]Coimbatore Tanjore

acaciae Mani

Schizomyia acaciae, MANI, *Rec. Indian Mus.*, 36 (4): 406 (1934)[1] [ex gall No. 207 on leaf of *Acacia leucophloea* Willd.]; *J. R. Asiatic Soc. Bengal*, 14 : 92, 139 (1948)[2]. — [1,2]Tanjore.

laporteae Felt

Schizomyia laporteae, FELT, *Treubia*, 1 : 143 (1921)[1] [ex gall on *Laportea stimulans Miq.*]; *Lingnan Sci. J.*, 7:462 (1929)[2]. — [1,2]Java

villebrunnaea Felt

Schizomyia villebrunneæ, FELT, *Treubia*, 1:146 (1921)[1] [ex gall on leaf of *Villebrunnea rubescens* Bl.]; *Lingnan Sci. J.*, 7:462 (1929)[2]. — [1,2]Java

acalypjae Felt

Schizomyia acalypahae, FELT, *Philipp. J. Sci.*, 13 : 281-325 (1918)[1] [ex gall on leaf of *Acalypha stipulacea* Klotz.]; *Lingnan Sci. J.*, 7:462 (1929)[2]. — [1,2]Java

diplodisci Felt

Schizomyia diplodisci, FELT, *Philipp. J. Sci.*, 13 : 281-325 (1918)[1] [ex gall on tender shoots of *Diplodiscus paniculatus* Turcz.]; *Lingnan Sci. J.*, 7: 462 (1929)[2]. — [1,2]Philippines

cheriani Mani

Schizomyia cheriani, MANI, *Rec. Indian Mus.*, 38 (4) : 194 (1936)[1] [ex gall No. 244 on flowers of *Ipomaea cairica* Sweet]; *J. R. Asiatic Soc. Bengal*, 14 : 92,146 (1948)[2].

[1]Madras
[2]Coimbatore

Cocculi Mani

Schizomyia cocculi, MANI, *Agra Univ. J. Res.*, (Sci)., 3 (1) : 109-112, fig. 1-4, (1954)[1] [ex gall No. 349 on flowers of *Cocculus hirsutus* Diels.].

[1]Coimbatore
Hydrabad S. India

nodosa Felt

Schizomyia nodosa, FELT, *Treubia*, 1 : 144 (1921)[1] [ex gall on *Moschosma polystachum* Benth.]; *Lingnan Sci. J.*, 7:462 (1929)[2].

[1,2]Java

incerta Kieffer

Schizomyia incerta, KIEFFER, *Marcellia*, 7 : 153 (1908); *Gen. Ins.*, 152 : 89 (1913) (larvae only) BRUNETTI, *Rec. Indian Mus.*, 17 : 10 (1920)[1]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 4 (1928)[2]. FELT, *Lingnan Sci.*, *J.*, 7 : 462 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 406 (1934)[3]; *J. R. Asiatic Soc. Bengal*, 14 : 92, 133 (1948)[4] [ex gall No. 177 on *Eurya japonica* Thumb].

[1,2]East Indies
[3,4]Kurseong

indica Kieffer

Schizomyia indica, KIEFFER, *Marcellia*, 7 : 154 (1908) [ex gall No. 250 on midrib of *Tecoma undulata* D. Don]; *Gen. Ins.*, 152 : 89 (1913)[1] (larvae only). BRUNETTI, *Rec. Indian Mus.*, 17 : 10 (1920). HOUARD, *Les. Zoocecides des plantes d' Afrique, d'Asie et d'Oceanie* 2 : 908 (1923). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 4 (1928)[2]. FELT, *Lingnan Sci. J.*, 7 : 462 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 406 (1934); *J. R. Asiatic Soc. Bengal*, 14 : 92,147 (1948)[3].

[1]India
[2]Kurseong
[3]East Indies

macarangae Nayar

Schizomyia macarangae, NAYAR, *Proc. Zool. Soc. Bengal*, 6 (2) : 131-134 (1953)[1], [ex gall on leaf of *Macaranga indica* Linn.].

[1]Travancore

48. **Diceromyia** Felt

Diceromyia, FELT, *Philipp. J. Sci.*, 13 : 283 (1918) [Genotype: *Diceromyia vernoniae* Felt]; *Bull. N. Y. St. Mus.*, 257 : 152 (1925); *Lingnan Sci. J.*, 7 : 440 (1929). MANI, *Indian J. Ent.*, 7 (1&2) : 209 (1946).

orientalis Felt

Diceromyia orientalis, FELT, *Treubia*, 9 : 388 (1927)[1] [ex gall on stem of *Phoebe delinata* Nees]; *Lingnan Sci. J.*, 7 : 462 (1929)[2] — [1,2]East Indies

vernoniae Felt.

Diceromyia vernoniae, FELT, *Philipp. J. Sci.*, 13 : 284 (1918)[1] [ex galls on leaf of *Vernonia lancifolia* Merr.]; *Lingnan Sci. J.*, 7 : 462 (1929).[2] — [1,2]Philippines

49. **Asphotrophia** Barnes

Asphotrophia, BARNES, *Hawaii Sugar Planters' Assoc., Expt. Sta. Bull.*, (Ent. Ser.), 19 : 23 (1928) [Genotype: *Asphotrophia fici* Barnes].

fici Barnes — [1,2]Philippines

Asphotrophia fici, BARNES, *Hawaii Sugar Planters' Assoc., Expt. Sta. Bull.*, (Ent. Ser.), 19 : 23 (1928)[1] [ex gall on figs of *Ficus nota*]. FELT, *Lingnan Sci. J.* 7 : 462 (1929)[2].

50. **Asphondylia** Herman Löw

Cecidomyia (partim), MEIGEN, *Syst. Beschr.*, 1 : 98 (1818).

Asphondylia, HERMAN LÖW, *Dipt. Beitrage*, 4 : 21 (1850) [Genotype: *Asphondylia sarothamni* Herman Löw]. WINNERTZ, *Linn. Ent.*, 8 : 187 (1853). OSTEN SACKEN, *Mon. N. Amer. Dipt.*, 1 : 176 (1862). SCHINER, *Fauna Austriaca*, 2 : 395 (1864). OSTEN SACKEN, *Trans. Amer. ent. Soc.*, p. 209 (1869). FELT, *Bull. N. Y. St. Mus.*, 124: 375 (1908). KIEFFER, *Gen. Ins.*, 152 : 91 (1913). FELT, *Bull. N. Y. St. Mus.*, 186 : 144 (1916). BRUNETTI, *Rec. Indian Mus.*, 17 : 10 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 151 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 4 (1928). FELT, *Lingnan Sci. J.*, 7 : 489 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 408 (1934); *Indian J. Ent.*, 7 (1&2) : 208 (1946).

Phyllophaga, RONDANI, *Dipt. Ital. Prodr.*, 1 : 199 (1856).

Cylindrocera, LIOY, *Atti. Inst. Veneto*, (3) 9 : 503 (1863).

Monasphondylia, KIEFFER, *Gen. Ins.*, 152 : 91 (1913).

beguni Mani

Asphondylia beguni, MANI, *Indian J. Ent.*, 15 (2) : 119-121, fig. (1953)[1] [ex flowers of *Solanum melongena*]. — [1]Hyderabad, Africa

bursaria Felt

Asphondylia bursaria, FELT, *Treubia*, 9 : 387 (1927)[1] [ex gall on stem of *Symplocos fasciculata* Zoll.]; *Lingnan Sci. J.*, 7 : 462 (1929)[2]. — [1,2]E. Indies

callicarpae Felt

Asphondylia callicarpae, Felt, *Philipp. J. Sci.*, 13 : 285 (1918)[1] [ex gall on leaf of *Callicarpa erioclona* Schaner]. Uichanco, *Philipp. J. Sci.*, 14 : 536-537 (1919). Felt, *Treubia*, 1:147 (1921)[2] [ex gall on *Polythalamus midris* and *Callicarpa longifolia* Linn.]; *Lingan Sci. J.*, 7:462 (1929)[3].

[1,3]Philippines
[2]Java

capsici Barnes

Asphondylia capsici, Barnes, *Ann. Mag. Nat. Hist., London* (9) 10 : 478 (1922)[1]. Mani, *Indian J. Ent.*, 15 (2) : 121 (1953)[2] [ex floswers of *Caspsicum*].

[1]Cyprus
[2]Hyderabad : Deccan

digerae Mani

Asphondylia digerae, Mani, *Indian J. Ent.*, 5: 153 (1943)[1] [ex gall No. 299 on ovary of *Digera arvensis* Förster]; *J. R. Asiatic Soc. Bengal*, 14 : 92, 148 (1948)[2].

[1,2]Delhi

grewiae Felt

Asphondylina grewiae, Felt, *Philipp. J. Sci.*, 14 : 287-94 (1919)[1] [ex gall on leaf of *Grewia stylocarpa* Warb.]; *Lingnan Sci., J.*, 7 : 462 (1929)[2].

[1,2]Philippines

ipomaeae Felt

Asphondylia ipomaeae, Felt, *Mem. Dept. Agric., India, Ent. Ser.*, 9 : 243 (1926)[1] [ex gall on *Ipomaea staphylina* Roem. & Sch.]. Senior-White, *Cat. Indian Ins.*, 15 : 5 (1928)[2]. Felt, *Lingnan Sci. J.*, 7 : 462 (1929)[3]. Mani, *Rec. Indian Mus.*, 36 (4) : 414 (1934)[4]; *J. R. Asiatic Soc. Bengal*, 14 : 92, 147 (1948) [ex gall No. 246 on buds and leaves of *Ipomaea staphylina* Roem & Sch.].

[1,2]Tanjore, Coimbatore

ixora Felt

Asphondylia ixora, Felt, *Treubia*, 9 : 388 (1927)[1] [ex gall on flowers of *Pavatta* (*Ixora*) *timoriensis* Decne].

[1]East Indies

lantanae Felt

Asphondylia lantanae, Felt, *Mem. Dept. Agric. India Ent. Ser.*, 7 : 2 (1920)[1] [ex galls on flowers of *Lantana camara* L.]. Senior-White, *Cat. Indian Ins.*, 15:5 (1928)[2]. Felt, *Lignan Sci. J.*, 7 : 462 (1929). Mani, *Curr. Sci.*, 2 : 146 (1933)[4]; *Rec. Indian Mus.*, 36 (4); 412 (1934) [ex gall on flowers of *Lantana indica* R.]; 40 (4): 333 (1938)[5].

[1,2]Kallar
[3]Pusa
[4,5]S. India

leeae Felt

Asphondylia leeae, Felt, *Treubia*, 1 : 148 (1921)[1] [ex gall on fruit of *Leea sambusina* Willd.]; *Lingnan Sci. J.*, 7 : 462 (1929)[2].

[1,2] Java

listeae Felt

Asphondylia listeae, Felt, *Treubia*, 1 : 149 (1921)[1] [ex gall on *Listea* sp.]; *Lingnan Sci. J.*, 7 : 462 (1929)[2].

[1,2] Java

menaschei Mani

Asphondylia menaschei, MANI, *Rec. Indian Mus.*, 39 (3): 283 (1937)[1].

[1]Calcutta

morindae Mani

Asphondylia morindae, MANI, *Ann. Mag. Nat. Hist.*, (10) 13:134 (1934)[1] [ex flower head gall No. 228 on *Morinda tinctoria* Roxb.]; *Rec. Indian Mus.*, 36 (4) : 409 (1934) [Biological Notes]; *ibid.*, 38 (2) : 194 (1936)[2] [ex gall on inflorescence of *Morinda tinctoria* Roxb.]; *J. R. Asiatic Soc. Bengal*, 14 : 92, 143 (1948)[3] [ex gall No. 228 on *Morinda tinctoria* Roxb.].

[1,3]Tanjore
[2,3]Coimbatore

osbeckiae Senior-White

Asphondylia osbeckiae, SENIOR-WHITE, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 83, 107 (1920)[1] [ex gall on flowers of *Osbeckia sp.*]; *Cat. Indian Ins.*, 15 : 5 (1928)[2]. FELT, *Lingnan Sci. J.*, 7 : 462 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 413 (1934).

[1,2]Shillong

phyllanthi Felt

Asphondylia phyllanthi, FELT, *Mem. Dept. Agric., Ent. Ser.*, 7 : 2 (1920)[1] [ex gall on leaf of *Phyllanthus emblica* L.]; *Treubia*, 9:385 (1927)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 5 (1928). FELT, *Lingnan Sci. J.*, 7 : 462 (1929)[3]. MANI, *Rec. Indian Mus.*, 36 (4):415 (1934); *J. R. Asiatic Soc. Bengal*, 14:92, 150 (1948)[4] [ex gall No. 262 on *Emblica officinalis* Gaertn].

[1,4]Burma
[2,3]E. Indies

pongamiae Felt

Asphondylia pongamiae. FELT, *Mem. Dept. Agric. India Ent. Ser.* 7 : 24 (1922)[1] [ex gall No. 202 on flower of *Pongamia glabra* Vent]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 5 (1928). FELT, *Lingnan Sci. J.*, 7 : 462 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 415 (1934); *J. R. Asiatic Soc. Bengal*, 14 : 92, 138 (1948)[2]. RAO, *Rec. Indian Mus.*, 48(3-4) : 36 (1950)[3].

[1,2]Coimbatore
[2]Tanjore, Calcutta
Dacca
[3]Bangalore

ricini Mani

Asphondylia ricini, MANI, *Bull. ent. Res.*, 38 (3) 439 (1947)[1] [ex gall on capsule of *Ricinus communis* Linn.]; *J. R. Asiatic Soc. Bengal*, 14 : 92 (1948)[2]. Rao, *Curr. Sci.*, 21 : 347-348, (1952) [Notes].

[1,2]Hyderabad

riveae Mani

Asphondylia riveae, MANI, *Rec. Indian Mus.*, 36 (4): 411 (1934)[1] [ex gall No. 247 on leaf of and gall

[1,2]Tanjore

No. 248 on flower of *Rivea hypocrateriformis* Choisy]; *J. R. Asiatic Soc. Bengal*, 14 : 92, 147 (1948)[2]

sesami Felt

Asphondylia sesami, FELT, *Can Ent.*, 48 : 31 (1916)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 11 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15:5 (1928)[3]. FELT, *Lingnan. Sci. J.*, 7 : 462 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 410 (1934) [ex gall on flowers, buds and fruits of *Sesamum indicum* Linn.]; *J. R. Asiatic Soc. Bengal*, 14 : 92, 148 (1948)[5] [ex gall No. 251 on flowers of *Sesamum indicum* Linn.].

[1,2,4] S. India
[3,4] Coimbatore
[5] Tanjore, Nadiad, Coimbatore, Nagpur, Calcutta

strobilanthi Felt

Asphonodylia strobilanthi, FELT, *Treubia*, 1 : 150 (1921)[4] [ex root gall on *Strobilanthus cernus* Bl.]; *Lingnan Sci. J.*, 7:462 (1929)[2].

[1,2] Java

tephrosiae Mani

Asphondylia tephrosiae, MANI, *Indian J., Ent.*, 5 : 152 (1943)[1] [ex gall No. 301 on ovary of *Tephrosia candida* De.]; *J. R. Asiatic Soc., Bengal.* 14 : 92, 152 (1948)[2].

[1,2] Delhi

trichocecidarum Mani

Asphondylia trichocecidarum, MANI, *Rec. Indian Mus.*, 36 (4) : 413 (1934)[1] [ex gall No. 206 on leaf of *Acacia leucophloea* Willd.]; *J. R. Asiatic Soc. Bengal*, 14 : 92, 139 (1948)[2].

[1,2] Tanjore

utriculae Mani

Asphondylia utriculae MANI, *Rec. Indian Mus.*, 36 (4) :410 (1934)[1] [ex gall No. 210 on ovary of *Dichrostachys cinera* W & A]; *J. R. Asiatic Soc. Bengal*, 14 : 92, 139 (1948)[2].

[1,2] Tanjore

vitea Felt,

Asphondylia vitea, FELT, *Philipp. J. Sci.*, 13 :284 (1918)[1]. [ex gall on stem of *Cissus trifolia* (L) K. Sch 8]; *Lingnan Sci. J.*, 7 : 462 (1929)[2].

[1] Manila
[2] E. Indies

viticola Kieffer

Asphondylia viticola, KIEFFER, *Marcellia*, 8 : 124 (1909)[1]. FELT, *Lingnan Sci. J.*, 7 : 462 (1929)[2].

[1,2] Java

51. **Daphnephila** Kieffer

Daphnephila, KIEFFER, *Ann. Soc. Sci. Bruxelles*, 29 : 144 (1908) [Genotype: *Daphnephila hassi* Kieffer]; *Gen. Ins.*, 152 : 96 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 11 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 153 (1925). SENIOR-WHITE, *Cat, Indian Ins.*, 15:5 (1928). FELT, *Lingnan Sci. J.*, 7 : 441 (1929).

MANI, *Rec. Indian Mus.*, 36 (4) : 415 (1934); *Indian J. Ent.*, 7 (1&2) : 209 (1945).

glandifex Kieffer

Daphnephila glandifex, KIEFFER, *Ann. Soc. Sci. Bruxelles*, 29 : 144 (1905); *Gen. Ins.*, 152 : 96 (1913)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 11 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 5 (1928). FELT, *Lingnan Sci. J.*, 7 : 462. MANI, *Rec. Indian Mus.*, 36 (4) : 415 (1934); *J. R. Asiatic Soc. Bengal*, 14 : 92, 149 (1948)[4] [ex gall No. 259 on stem of *Machilus gamblici* King]. — [1,2,3]Bengal [4]Kurseong

linderae Kieffer

Daphnephila linderae, KIEFFER, *Ann. Soc. Sci. Bruxelles*, 29 : 144 (1905); *Gen. Ins.*, 152 : 96 (1913)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 11 (1920). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 6 (1928). FELT, *Lingnan Sci. J.*, 7 : 462 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 415 (1934); *J. R. Asiatic Soc. Bengal*, 14 : 92, 149 (1948)[4] [ex gall No. 258 on *Lindera pulcherrima* Benth.]. — [1,2,3]Bengal [4]Kurseong

haasi Kieffer

Daphnephila haasi, Kieffer, *Ann. Soc. Sci. Bruxelles*, 29 : 144 (1905); *Gen. Ins.*, 152 : 96 (1913)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 11 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 6 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 415 (1934); *J. R. Asiatic Soc. Bengal*, 14 : 92, 150 (1948)[4] [ex gall No. 260 on leaf of *Machilus gamblei* King].

52. **Meterdiplosis** Barnes

Meterdiplosis, BARNES, *J. Fed. Malaya St. Mus.*, 13 : 272 (1927) [Genotype : *Meterdiplosis nigrolineata* Barnes]. FELT, *Lingnan Sci. J.*, 7 : 440 (1929). MANI, *Indian J. Ent.*, 7 (1&2) : 209 (1945).

nigrolineata Barnes

Meterdiplosis nigrolineata, BARNES, *J. Fed. Malaya St. Mus.*, 13 : 272 (1927)[1]. FELT, *Lingnan Sci. J.* 7 : 462 (1928)[2]. — [1,2]Malya states

53. **Acroectasis** Rübsaamen

Acroectasis, RUBSAAMEN, *Z. wiss. Insektenbiol.*, 6 : 131, (1910) [Genotype: *Acroectasis maura* Rübs.]. Kieffer, *Gen. Ins.*, 152 : 113 (1913). FELT, *N. Y. St. Mus.*, *Bull.* 257 : 152 (1925). MANI, *Indian J. Ent.*, 7: 208 (1946).

campanulata Mani

Acroectasis campanulata, MANI, *Agra Univ. J. Res.* (Sci) 3 (1) : 17-19, 29,pl. vii, figs. (1954) [ex gall No. 500 on branches of *Sabia campanulata*].

[1]Dalhousie: Himalayas

54. **Oxasphondylia** Felt

Oxasphondylia, FELT, *Proc. U. S. nat. Mus.*, 48 : 204 (1915); *N. Y. St. Mus.*, *Bull.*, 257 : 152, (1925); *Lingnan Sci. J.*, 7:440, (1929). MANI, *Indian J. Ent.*, 7 : 208, (1946).

dosua Mani

Oxasphondylia dosua, MANI, *Agra Univ. J. Res.* (Sci.) 3 (1) : 22, (1954)[1] [ex gall No. 483 on *Indigofera dosua* Ham.].

[1]Kangra Valley

echinata Mani

Oxasphondylia echinata, MANI, *Agra Univ. J. Res.* (Sci). 3 (1) : 20 (1954)[1] [ex gall No. 486 on *Indigofera geradiana* Wall.].

[1]Kangra Valley

floricola Mani

Oxasphondylia floricola, MANI, *Agra Univ. Rep.* (Sci.) 3 (1) : 25 (1954)[1] [ex gall No. 490 on flowers of *Indigofera gerardiana* Wall.].

[1]Dalhousie: Himalayas

Tribe BIFILINI

55. **Dentifibula** Felt

Contarinia (partim), FELT, *Rec.* 22 *N. Y. St. Mus.*, 110 : 131 (1907).

Dentifibula, FELT, *Bull. N. Y. St. Mus.*, 124 : 387 (1908) [Genotype: *Dentifibula viburni* Felt]; *J. N. Y. ent. Soc.*, 19 : 51 (1911). KIEFFER, *Gen. Ins.*, 152: 174 (1913). FELT, *Bull. N. Y. St. Mus.*, 262 : 129 (1918). BRUNETTI, *Rec. Indian Mus.*, 17: 13 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 157 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15: 9 (1928). FELT, *Lingnan Sci. J.*, 7 : 444 (1929). MANI, *Rec. Indian Mus.*, 36 (4); 420 (1934); *Indian J. Ent.*, 7 (1&2): 211 (1946).

ceylanica Felt

Dentifibula ceylanica, FELT, *J. N. Y. ent. Soc.*, 23 : 175 (1915)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 13 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 9 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 464 (1929). MANI, *Rec. Indian Mus.*, 36(4) : 420 (1934).

[1,2,3]Ceylon

obtusilobae Felt

Dentifibula obtusilobae, Felt, *J. N. Y. ent. Soc.*, 23 : 176 (1915)[1]. Brunetti, *Rec. Indian Mus.*, 17 : 13 (1920)[2]. Senior-White, *Cat. Indian Ins.*, 15 : 9 (1928)[3]. Felt, *Lingnan Sci. J.*, 7 : 464 (1929). Mani, *Rec. Indian Mus.*, 36 (4); 420 (1934).

[1,2,3]Ceylon

56. **Myricomyia** Kieffer

Diplosis (partim), Fr. Löw, *Verh. Zool. - bot. Ges. Wien.*, 35 : 485 (1895).

Contarinia (partim), Kertesz, *Cat. Dipt.*, 2 : 96(1900).

Myricomyia, Kieffer, *Ann. Soc. Ent. France.*, 69 : 470 (1900) [Genotype; *Myricomyia longipalpis* Kieffer]; *Gen. Ins.*, 152 : 185 (1913). Felt, *Bull. N. Y. St. Mus.*, 257 : 157 (1925); *Lingnan Sci. J.*, 7 : 444 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 420 (1934); *Indian J. Ent.*, 7 (1&2) : 420 (1946).

pongamiae Mani

Myricomyia pongamiae, Mani, *Rec. Indian Mus.*, 36 (4): 420 (1934)[1] [ex gall No. 201 on shoots of *Pongamia glabra* Vent]; *J. R. Asiatica Soc. Bengal*, 14 : 93, 138 (1948)[2].

[1,2]Tanjore.

57. **Kronodiplosis** Felt

Kronodiplosis, Felt, *Philipp. J. Sci.*, 13 : 289 (1918) [Genotype: *Kronodiplosis unichancoi* Felt]; *Bull. N. Y. St. Mus.*, 257 : 157 (1925); *Lingnan Sci.*, *J.*, 445 (1929). Mani, *Indian J.*, *Ent.*, 7 (1&2) : 211 (1946).

uichancoi Felt

Kronodiplosis uichancoi, Felt, *Philipp. J. Sci.*, 13 : 289 (1918)[1] [ex gall on leaf of *Barringtonia luzonensis* Rolfe.]; *Lingnan Sci. J.*, 7 : 464 (1929).

58. **Odinadiplosis** Mani

Odinadiplosis, Mani, *Rec. Indian Mus.*, 37 (4) : 435 (1935) [Genotype: *Odinadiplosis odinae* Mani]. Barnes, *J. S. E. Agric. College, Wye*, 38 : 75-77 (1936). Mani, *Rec. Indian Mus.*, 40 (4) : 336 (1938); *Indian J. Ent.*, 7 (1&2) : 211 (1946).

odinae Mani

Odinadiplosis odinae, Mani, *Rec. Indian Mus.*, 37 (4) : 436 (1935)[1] [ex gall No. 198 on leaf of *Odina wodier* Roxb.]; *Rec. Indian Mus.*, 40 (4) : 336 (1938); *Indian J. Ent.*, 5 : 160 (1943)[2]; *Bull. Ent. Res.*, 38 (3) : 441 (1947)[3]; *J. R. Asiatic Soc. Bengal*, 14 : 93, 137 (1948)[4]; *Agra univ. J. Res.* (Sci.) 2 : 140 (1953)[5].

[1]Tanjore, Calcutta
[2]Udiapur
[3]Jhabua
[4]Tanjore, Vellore Udaipur, Calcutta
[5]Ramgarh

59. **Streptodiplosis** Felt

Streptodiplosis, Felt, *Can. Ent.*, 48 : 405 (1916) [Genotype: *Streptodiplosis indica* Felt]. Brunetti, *Rec. Indian Mus.*, 17:13 (1920). Felt, *Bull. N. Y. St. Mus.*, 257 : 154 (1925). Senior-White, *Cat. Indian Ins.*, 15 : 9 (1928). Mani, *Rec. Indian Mus.*, 36 (4): 416 (1934); *Indian J. Ent.*, 7 (1&2) : 212 (1945).

indica Felt

Streptodiplosis indica, Felt, *Can Ent.*, 48 : 405 (1916)[1]. Brunetti, *Rec. Indian Mus.*, 17 : 13 (1920)[2]. Senior-White, *Cat. Indian Ins.*, 15 : 9 (1928). Felt, *Lingnan Sci. J.*, 7 : 464 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 416 (1934).

[1],[2]Kusti

60. **Lobopteromyia** Felt

Contarinia (partim), Felt, *Rep.* 22 *N. Y. St. Mus.*, 110: 131 (1907).

Lobopteromyia, Felt, *Bull. N. Y. St. Mus.*, 124 : 389 (1908) [Genotype: *Lobopteromyia filicilis* Felt]. Kieffer, *Gen. Ins.*, 152 : 176 (1913). Felt, *Bull. N. Y. St. Mus.*, 257 : 154 (1925); *Lingnan Sci. J.*, 7 : 462 (1929). Mani, *Indian J. Ent.*, 7 (1&2) : (1946).

bivalviae (Rao)

Clincticornia bivaliviae, Rao, *Rec. Indian Mus.*, 48 (3-4): 35-37, fig. 3-4, (1950) . (ex gall No. 209 on liafleto of *Acacia catetchu* Willd.).

Lobopteromyia bivalviae, Mani, *Agra Univ. J. Res.*, (Sci). 2 (2) : 251, 260-262, pl. v, (1953)[2] [ex Gall No. 209 on leaflets of *Acacia catechu* Willd.]

[1]Bombay
[2]Walayar: S. India
Hyderabad: Deccan; Thana : Bombay

prosopidis Mani

Lobopteromyia prosopidis Mani, *Rec. Indian Mus.*, 40 (4) : 334 (1936)[1] [ex gall No. 212 on rachis of *Prosopis spicigera* Linn. and gall No. 211 on *Prosopis juliflora*]; *J. R. Asiatic Soc., Bengal*, 14 : 92, 139 (1948)[2].

[1],[2]Tanjore
[2]Delhi

ramachandrani Mani

Lobopteromyia ramachandrani, Mani, *Agra Univ. J. Res.* (Sci.) 2 (2) : 262, fig 1-3, pl. v, (1953)[1] (ex gall No. 456 on leaflets of *Acacia suma*).

[1]Walayar : S. India

61. **Thurauia** Rübsaamen

Thurauia, Rübsaamen, *W. Ent. Z.*, 18 : 58 (1809) [Genotype: *Thurauia aquatica* Rübsaamen]. Kieffer, *Gen. Ins.*, 152 : 175 (1913). Felt, *Bull. N. Y. St.*

Mus., 257 : 155 (1925); *Lingnan Sci. J.*, 7 : 442 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 416 (1934); *Indian J. Ent.*, 7 (1&2) : 212 (1946).

chilkaensis Mani

Thurauia chilkaensis, MANI, *Rec. Indian Mus.*, 36 (4) 416 (1934)[1] . [1]Chilka lake

62. **Anjeerodiplosis** Mani

Anjeerodiplosis, MANI, *Rec. Indian Mus.*, 40 (4) : 333 (1938) [Genotype: *Anjeerodiplosis peshawarensis* Mani]; *Indian J. Ent.*, 7 (1&2) : 212 (1946).

peshawarensis Mani

Anjeerodiplosis peshawarensis, MANI, *Rec. Indian Mus.*, 40 (4) : 333 (1938)[1] [ex gall on figs of *Ficus carica*]; *Indian J. Ent.*, 5:156 (1944) [Biological Notes] [1]Peshawar

63. **Endaphis** Kieffer

Endaphis, KIEFFER, *Bull. Soc. Ent. France*, p. 383 (1896) [Genotype: *Endaphis perfidus* Kieffer]. FELT, *Ent. News*, 22 : 128 (1911). KIEFFER, *Gen. Ins.*, 152 : 171 (1913). BRUNETTI, *Rec. Indian Mus.*, 17:8 (1920). FELT, *Bull. N. Y. St. Mus.*, 257:155 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15:8 (1928). FELT, *Lingnan Sci. J.*, 7 : 443 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 418 (1934); *Indian J. Ent.*, 7 (1&2) : 213 (1946).

Feltodiplosis, SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 8 (1928).

hirta Felt

Endaphis hirta, FELT, *Ent. News.*, 22 : 224 (1911)[1]. MANI, *Rec. Indian Mus.*, 36 (4): 418 (1934). [1,2,3]Ceylon

Feltodiplosis hirta, KIEFFER, *Gen. Ins.*, 152:155 (1913)[2]. BRUNETTI, *Rec. Indian Mus.*, 17 : 12 (1920)[3]. SENIOR-WHITE, *Cat. Indian Ins.*, 15:8 (1928)[4].

64. **Procontarinia** Kieffer & Cocconi

Procontarinia, KIEFFER & COCCONI, *Marcellia*, 5:135 (1906) [Genotype: *Procontarinia matteiana* Kieffer & Cocconi]. KIEFFER, *Gen. Ins.*, 152:183 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 13 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 155 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 10 (1928). FELT, *Lingnan Sci. J.*, 7 : 443 (1929). MANI, *Rec. Indian Mus.*, 36 (4) :420 (1934); *Indian J. Ent.*, 7 (1&2): 212 (1946).

matteiana Kieffer & Cocconi

Procontarinia matteiana, KIEFFER & COCCONI, *Marcellia*, 5:135-136 (1906)[1] [ex gall No. 192 on leaf of *Mangifera indica* Linn.]. STEFANI-PEREZ, *Marcellia*, 5 : 165 (1906). KIEFFER, *Gen. Ins.*, 152 : 83 (1913)[2]. BRUNETTI, *Rec. Indian Mus.*, 17 : 13 (1920)[3]. FELT, *Treubia*, 1 : 139-151 (1921)[4]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 10 (1928). FELT, *Lingnan Sci. J.*, 7 : 464 (1929). MANI, *Rec. Indian Mus.*, 36 (4):420 (1934); *Indian J. Ent.*, 5:159 (1943)[5]; *J. R. Asiatic Soc. Bengal*, 14 : 93,137 (1948). Rao, *Proc. R. ent. Soc., London*, (B) 21 (3-4): 54 (1952)[6].

[1,2,3]India
[4]Java
[5]Punjab
[6]Kanpur
Calcutta
Coimbatore
Dehra Dun
Ranchi
Tanjore

65. **Contarinia** Rondani

Tipula (partim), De GEER, *Mem. P. Serv. a l'inst. des Ins.*, 6 : 420 (1776).

Cecidomyia (partim), LATREILLE, *Gen. Crust. et Ins.*, 4 : 253 (1809).

Diplosis (partim), H. LÖW, *Dipt. Beitr.*, 4 : 34 (1850).

Contarinia, RONDANI, *Atti. Soc. Sci. Nat. Milano*, 2 : 287 (1860) [Genotype: *Contarinia loti* (De Geer)]. KIEFFER, *Wien Ent. Z.*, 15 : 94, 98-99 (1896); *Ann. Soc. Ent. France*, 49:447 (1900). FELT, *Bull. N. Y. St. Mus.*, 124 : 390 (1908). KERT., *Cat., Dipt.*, 2:91 (1909). KIEFFER, *Gen. Ins.*, 152 : 178 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 270 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 155 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 10 (1928). FELT, *Lingnan Sci. J.*, 7 : 443 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 418 (1934); *Indian J. Ent.*, 7 (1&2): 213 (1946).

Eudiplosis, KIEFFER, *Bull. Soc. Ent. France*, 63 : 28 (1894).

Stictodiplosis (partim), KIEFFER, *Bull. Soc. Ent. France*, 63:28 (1894).

andropoginis Felt

Contarinia andropoginis, FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 25 (1921)[1]. BALLARD, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 23-24 (1920) [Bionomics]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 10 (1928)[2]. FELT, *Lingnan Sci. J.*, 7 : 454 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 419 (1934)[3] [ex gall on earheads of *Andropogon sorghum* Brot.]; *J. R. Asiatic Soc. Bengal*, 14 : 93 (1948)[4].

[1,2]Coimbatore
[3,4]Tanjore

caudata Felt

Contarinia caudata, Felt, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 4 (1920)[1] [ex gall on *Apluda varia* Hack.]; *ibid.*, 7 : 16 (1921) [ex gall on *Andropogon schoenanthus* Linn.]. Senior-White, *Cat. Indian Ins.*, 15 : 10 (1928)[2]. Felt, *Lingnan Sci. J.*, 7 : 464 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 419 (1934)[3] [ex gall on *Andropogon contortus* L.]; *J. R. Asiatic Soc. Bengal*, 14 : 93,152 (1948)[4].

[1,2]Coimbatore
[3]Tanjore
[4]South India

dalbergiae Mani,

Contarinia dalbergiae, Mani, *Indian J. Ent.*, 4 (1) : 43 (1942)[1] [ex gall on flowers of *Dalbergia Sissoo*].

[1]Dehra Dun

pulcherrima Kieffer

Contarinia pulcherrima, Kieffer, *Rec. Indian Mus.*, 3 : 130 (1909)[1]. Mani, *J. R. Asiatic Soc. Bengal*, 14: 93, 145 (1948).

Stictodiplosis pulcherrima, Kieffer, *Gen. Ins.*, 152 : 183 (1913)[2] [*Bulchripennis laps*]. Brunetti, *Rec. Indian Mus.*, 17 : 13 (1920)[3]. Senior-White, *Cat. Indian Ins.*, 15 : 10 (1928). Felt, *Lingnan Sci. J.*, 7 : 464 (1929). Mani, *Rec. Indian Mus.*, 36 (4): 419 (1934); *ibid.*, 38 (2) : 195 (1936).

[1,3]Kurseong
[2]E. Indies

saltata Felt

Contarinia saltata, Felt, *Philipp. J. Sci.*, 14 : 287-294 (1919)[1] [ex gall on *Andropogon sorghum* Bort.]; *Lingnan Sci. J.*, 7 : 464 (1929).

[1]Philippines

66. **Stictodiplosis** Kieffer

Diplosis (partim), Löw, *Dipt. Beitr.* 44 : 29 (1850).

Stictodiplosis, Kieffer, *Bull. Soc. Ent.* France, 63 : 28 (1894) [Genotype: *Stictodiplosis nubilipennis* Kieffer]. *Gen. Ins.*, 152: 183 (1913). Brunetti, *Rec. Indian Mus.*, 17 : 13 (1920). Felt, *Bull. N. Y. St. Mus.*, 257: 155 (1925). Senior-White, *Cat. Indian Ins.*, 15 : 10 (1928). Felt, *Lingnan Sci. J.*, 7 : 466 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 419 (1934); *Indian J. Ent.*, 7 (1&2) : 119 (1946).

tephrosiae Mani

Stictodiplosis tephrosiae, Mani, *Indian J. Ent.*, 5 : 157 (1943)[1] [ex gall on flower buds of *Tephrosia candida*]; *J. R. Asiatic Soc., Bengal*, 14 : 93 (1948)[2].

[1,2]Delhi

moringae Mani

Stictodiplosis moringae, Mani, *Rec. Indian Mus.*, 28 (2): 195 (1936)[1] [ex gall on *Moringa* buds]

[1]Coimbatore

67. **Toxomyia** Felt

Toxomyia, FELT, *Ent. News.*, *Philadalphia*, 22 : 302 (1911) [Genotype: *Toxomyia fungicola* Felt]. KIEFFER, *Gen. Ins.*, 152 : 173 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 154 (1925); *Lingnan Sci. J.*, 7 : 442 (1929). MANI, *Indian J. Ent.*, 7 : 213 (1946).

brideliae Felt

Toxomyia brideliae, FELT, *Philipp. J. Sci.*, 17 : 231-234 (1920)[1] [ex gall on leaf of *Bridelia stipularis*]; *Mem. Dept. Agric. Indian*, *Ent. Ser.* 9 : 241-245 (1926)[2]; *Lingnan Sci. J.*, 7:464 (1929). — [1]Philippine [2]East India

68. **Indodiplosis** Felt

Indodiplosis, FELT, *Can. Ent.*, 48: 403 (1916) [Genotype: *Indodiplosis mangiferae* Felt]. BRUNETTI, *Rec. Indian Mus.*, 17 : 13 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 154 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 9 (1928). FELT, *Lingnan Sci. J.*, 7 : 442 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 415 (1934); *Indian J. Ent.*, 7 (1&2) : 213 (1946).

mangiferae Felt

ndodiplosis mangiferae, FELT, *Cat. Ent.*, 48 : 403 (1916)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 13 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 9 (1928). FELT, *Lingnan Sci. J.*, 7 : 464 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 415 (1934); *J. R. Asiatic Soc. Bengal.*, 14 : 92, 147 (1948) [ex gall No. 193 on *Mangifera indica* Linn.]. — [1,2]Pusa

69. **Sissudiplosis** Mani

Sissudiplosis, MANI, *Indian J. Ent.*, 4 (1) : 44 (1942) [Genotype: *Sissudiplosis chatterjeei* Mani]; *Ibid.*, 7 (1&2): 213 (1946).

chatterjeei Mani

Sissudiplosis chatterjeei, MANI, *Indian J. Ent.*, 4 (1) : 44 (1942)[1] [ex gall on leaf of *Dalbergia sissoo*]. — [1]Dehra Dun

70. **Bungomyia** Nayar

Bungomyia, NAYAR, *Proc. R. ent. Soc. London*, (B) 18 (5-6): 85 (1949) [Genotype: *Bungomyia brachyrhyncha* Nayar].

brachyrhyncha Nayar

Bungomyia brachyrhynacha, NAYAR, *Proc. R. ent. Soc.* London, (B) 18 (5-6) : 86 (1949)[1]. — [1]Calcutta

71. **Amradiplosis** Mani

Amradiplosis, Mani, *Bull. ent. Res. London*, 38 (3) : 441, (1947) [Genotype: *Amradiplosis echinogalliperda* Mani]; *Agra Univ. J. Res.* (Sci.) 1 : 49 (1952).

Amraemyia, Rao, *Indian J. Ent.*, 10 (1) : 33 (1948).

amraemyia (Rao)

Amraemyia amraemyia, Rao, *Indian J. Ent.*, 10 : 37, (1948).

Amradiplosis amraemyia, Mani, *Agra Univ. J. Res.*, (Sci.) 1 : 51, (1952)[1] [ex gall No. 325 on *Mangifera indica* Linn.].

[1]India. Kanpur

brunneigallicola (Rao)

Amraemyia brunneigallicola, Rao, *Indian J. Ent.*, 10 : 39 (1948).

Amradiplosis brunneigallicola, Mani, *Agra Univ. J. Res.* (Sci.), 1 : 51 (1952)[1] [ex gall No. 326 on *Mangifera indica* Linn.].

[1]India Kanpur

echinogalliperda Mani

Amradiplosis echinogalliperda, Mani, *Bull. ent. Res. London*, 38 (3) : 443 (1947) ; *J. R. Asiatic Soc. Bengal*, (Sci.) 14 : 92, (1948); *Agra Univ. J. Res.* (Sci.) 1 : 50 (1952)[1] [gall No. 196 on *Mangifera indica* Linn.].

[1]Calcutta, Dehra Dun

keshopurensis (Rao)

Amraemyia keshopurensis, Rao, *Proc. R. ent. Soc. London*, (B) 21 (3-4) : 52 (1952).

Amradiplosis keshopurensis, Mani, *Agra Univ. J. Res.* (Sci.) 1 : 51, (1952)[1] [ex gall No. 332 on *Mangifere indica* Linn.].

[1]India Keshopur

viridigallicola (Rao)

Amraemyia viridigallicola, Rao, *Indian J. Ent.*, 10 : 34 (1950).

Amradiplosis viridigallicola, Mani, *Agra Univ. J. Res.* (Sci.) 1 : 50 (1952)[1]. [ex gall No. 324 on *Mangifera indica* Linn.].

[1]India

Tribe TRIFILINI

72. **Trisopsis** Kieffer

Trisopsis, Kieffer, *Boll. Labor. Zool. Portici*, 6 : 171 (1912) [Genotype: *Trisopsis oleae* Kieffer]; *Gen. Ins.*, 152 : 136 (1913). Felt, *Bull. N. Y. St. Mus.*, 257 : 171 (1925); *Lingnan Sci. J.*, 7 : 457 (1929). Mani, *Rec. Indian Ent.*, 7 (1&2) : 214 (1946).

travancoricus Nayar

Trisopsis travancoricus, NAYAR, *Proc. R. ent. Soc., London*, (B) 18 (5-6)-87 (1949)[1] .

[1]Trivandrum

73. **Horidiplosis** Felt

Horidiplosis, FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 10 (1920) [Genotype: *Horidiplosis fici* Felt]; *Bull. N. Y. St. Mus.*, 257 : 175 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 7 (1928). FELT, *Lingnan Sci. J.*, 7 : 460 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 442 (1934); *ibid.*, 37 (4) : 439 (1935); *Indian J. Ent.*, 7 (1&2) : 228 (1946).

mathuri Mani

Horidiplosis mathuri, MANI, *Rec. Indian Mus.*, 37 (4): 440 (1935)[1] [ex gall No. 265 on leaves of *Ficus glomerata* Roxb.]; *J. R. Asiatic Soc. Bengal*, 14 : 94, 150 (1948)[2].

[1,2]Dehra Dun

fici Felt

Horidiplosis fici, FELT, *Mem. Dept. Agric. India, Ent.* Ser., 7 : 10 (1920)[1] [ex gall No. 266 on leaf of *Ficus infectoria* Roxb.]; *ibid.*, 9 : 241-245 (1926)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15:7 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 464 (1929). MANI, *Rec. Indian Mus.*, 36 (4) :442 (1935); *ibid.*, 37 (4) :438 (1935); *J. R. Asiatic Soc. Bengal*, 14 : 94, 151 (1948)[4].

[1,3,4]Pusa
[2]E. Indies

74. **Gnesiodiplosis** Tavares

Gnesiodiplosis, TAVARES, *Broteria, S. Zool.*, 15 : 162 (1917) [Genotype: *Gnesiodiplosis itaparicae* Tavares]. FELT, *Bull. N. Y. St. Mus.*, 257 : 175 (1925); *Lingnan Sci. J.*, 7 : 460 (1929). MANI, *Indian J. Ent.*, 7 (1&2) : 228 (1946).

garcinia Felt

Gnesiodiplosis garcinia, FELT, *Treubia*, 9 : 388 (1927)[1] [ex gall on *Garcinia dioica* Bl.]; *Lingnan Sci. J.* 7 : 464 (1929).

[1]East Indies

75. **Orseolia** Kieffer & Massalongo

Orseolia, KIEFFER & MASSALONGO, *Marcellia*, 1 : 56 (1902) [Genotype: *Orseolia cynodontis* Kieffer & Massalonga]. KIEFFER, *Gen. Ins.*, 152 : 151 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 173 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 7 (1928). FELT, *Lingnan Sci. J.*, 7: 459 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 442 (1934); *Indian J. Ent.* 7 (1&2) : 227 (1946).

cynodontis Kieffer & Massalongo

Orseolia cynodontis KIEFFER & MASSALONGO, *Marcellia*, 1 : 57 (1902)[1]. KIEFFER, *Gen. Ins.*, 152 : 152 (1913)[2]. [ex gall on *Cynodon dactylon* Pers.]. FELT, *Mem. Dept. Agric. India Ent. Ser.*, 7 : 16 (1921)[3] [ex gall on *Panicum fluitans Retz.*,]. RAO, *Proc. V ent. Meet.*, *Pusa*, p. 272 (1923)[4]. FELT, *Mem. Dept. Agric. India*, *Ent. Ser.*, 9 : 241-245 (1924)[5]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 7 (1928). FELT, *Lingnan Sci. J.*, 7 : 464 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 442 (1934); *J. R. Asiatic* Soc. Bengal, 14 : 93,153 (1948)[6].

[1]Italy
[2]Algeria, Ceylon
[3]South India
[4]Comibatore
[5]E. Indies
[6]Java, India, Moracco, Algeria, Syria, Eritrea

76. **Courteia** Kieffer

Courteia, KIEFFER, *Marcellia*, 8 : 131 (1909) [Genotype: *Courteia graminis* Kieffer]; *Gen. Ins.*, 152 : 153 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 238 (1925); *Lingnan Sci. J.*, 7 : 459 (1929).

graminis Kieffer

Courteia graminis, KIEFFER, *Marcellia*, 8 : 131 (1909) [1] [ex gall on *Panicum nodosum* Kunth.]; *Gen. Ins.*, 152 : 154 (1913). FELT, *Lingnan Sci. J.*, 7 : 464 (1929). MANI, *J. R. Asiatic Soc. Bengal*, 14 : 153 (1948).

[1]Java

77. **Microplecus** Kieffer

Microplecus, KIEFFER, *Bull. Soc. Hist. Nat. Metz.*, 28 : 107 (1913) [Genotype: *Microplecus brevipalpi* Kieffer]; *Gen. Ins.*, 152 : 190 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 170 (1925); *Lingnan Sci. J.*, 7:456 (1929). MANI, *Indian J. Ent.*, 7 : 225 (1946). Rao, *Rec. Indian Mus.*, 50 : 317 (1952).

longipalpi Rao

Microplecus longipalpi, Rao, *Rec. Indian Mus.*, 50:317-319, fig. 6 (1952)[1].

[1]Agra

78. **Dyodiplosis** Rübsaamen

Hormomyia (partim), RÜBSAAMEN, *Biol. Centralblatt.* 19: 602 (1899).

Dyodiplosis, RUBSAAMEN, *Z. Wiss. Insektenbiol.*, 8 : 49 (1912) [Genotype: *Dyodiplosis arenariae* Rübsaamen]. KIEFFER, *Gen. Ins.*, 152 : 205 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 14 (1920). FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 17-18 (1921) [Key to Indian Spp.]; *Bull. N. Y. St. Mus.*, 231-232 : 208 (1921); *ibid.*, 257 : 170 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 12 (1928). FELT, *Lingnan Sci. J.*, 7 : 456 (1929). MANI, Rec. Indian Mus., 36 (4) : 441 (1934); *Indian J. Ent.*, 7 (1&2) : 224 (1946).

andropoginis Felt

Dyodiplosis andropoginis, FELT, *Ent. News.*, 28 : 369 (1917)[1] [ex gall on *Andropogon annulatus* Forsk.]; *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 15,16,17 (1921)[2] [ex gall on *Apludia varia* Hack.; *Andropogon annulatus* Forsk. *A. contortus* L.; *A. pertusus* Willd., *A. schoenanthus* Linn., *Panicum flavidum* Retz.]. Y. R. RAO, *Proc. V ent. Meet., Pusa*, p. 272 (1923)[3]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 12 (1928)[4]. FELT, *Lingnan Sic. J.*, 7 : 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 442 (1936); *J. R. Asiatic Soc. Bengal*, 14 : 152 (1948)[5].

[1,2,3,4]Adoni
[2,3,4]Coimbatore
Samalkot
[3,4,5]S. India

cornea Felt

Pseudohormomyia cornea, FELT, *Ent. News*, 28 : 76 (1917)[1] [ex gall on *Ischaemum ciliare*]. BRUNETTI, *Rec. Indian Mus.*, 17 : 15 (1920)[2]. *Pusa Bull.*, 89 : 45 (1920)[3].

Dyodiplosis cornea, FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 17 (1921)[4] [ex gall on side shoots of *Ischaemum ciliare*]. Y. R. RAO, *Proc. V ent. Meet. Pusa*, p. 272 (1923)[5]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 12 (1928)[6]. FELT, *Lingnan Sci. J.*, 7 : 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 442 (1934).

[1,2,3,4,5,6]Coimbatore

fici Rao

Dyodiplosis fici, RAO, *Indian. J. Ent.*, 11 (2) : 123 (1951)[1] [ex gall No. 264 on leaf of *Ficus glomerata* Roxb.].

[1]Agra

fluvialis Felt

Pseudohormomyia fluvialis, FELT, *Ent. News*, 28 : 74 (1917)[1] [ex gall on side and terminal shoots of *Panicum flutians*]. BRUNETTI, *Rec. Indian Mus.*, 17 : 15 (1920)[2].

[1,2,5]South India

Dyodiplosis fluvialis, FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 16 (1921)[3] [ex gall on *Cynodon dactylon, Panicum flutians*]. Y. R. RAO, *Proc. V ent. Meet. Pusa*, p. 273 (1923)[5]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : (1928). FELT, *Lingnan Sci. J.*, 7 : 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 442 (1934).

generosi Felt

Dyodiplosis generosi, FELT, *J. N. Y. ent. Soc.*, 23 : 183 (1915)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 15 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 12 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 442 (1934).

[1,2,3]Ceylon

indica Felt

Dyodiplosis indica, FELT, *Mem. Dept. Agric. India* (*Ent. Ser.*) 7 : 15-19 (1921)[1] [ex gall on *Andropogon Shoenanthus*]. SENIOR-WHITE, *Cat. Indian Ins.*, 15: 12 (1928)[2]. FELT, *Lingnan Sci. J.*, 7:463 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 442 (1934).

[1,2]Ballary Dist

monticola Felt

Dyodiplosis monticola, FELT, *Mem. Dept. Agric. India*, *Ent. Ser.*, 7 : 20 (1921)[1] [ex gall on *Andropogon monticola* Schult]. RAO, *Proc. V ent. Meet., pusa.*, p. 272 (1923)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 12 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 442 (1934); *J. R. Asiatic Soc. Bengal*, 14 : 152 (1948).

[1,2,3]Ballary Dist

plumosa Felt

Dyodiplosis plumosa FELT, *Mem. Dept. Agric.*, *India Ent. Ser.*, 7 : 21 (1921)[1] [ex gall on *Andropogon annulatus* on *Iseilema laxum* Hack.] Y. R. RAO, *Proc. V ent. Meet. Pusa.*, p. 272 (1923)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15: 13 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4) :442 (1934); *J. R. Asiatic Soc. Bengal*, 14 : 9 153 (1948).

[1,2,3]Atchanta, Samalkot

79. **Hormomyia** H. Löw

Cecidomyia (partim), MEIGEN, *Syst. Beschr.*, 1 : 94 (1818).

Hormomyia, H. Löw, *Dipt. Beitr.*, 4 : 20,31 (1850) [Genotype: *Hormomyia dubitata* (Rübsaamen)]. FELT, *Bull. N. Y. St. Mus.*, 124 : 387 (1908); *J. N. Y. ent. Soc.*, 19 : 57 (1911). KIEFFER, *Gen. Ins.*, 152 : 137 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 271 (1920). FELT, *Bull. N. Y. St. Mus.*, 231-232 : 209 (1921); *ibid.* 257 : 170 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 6 (1928). FELT, *Lingnan Sci. J.*, 7 : 456 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 441 (1934); *Indian J. Ent.*, 7 (1&2):225 (1946).

Cecidomyia (partim), ZETTERSTEDT, *Dipt. Scandinav.*, 9: 3677 (1850).

Angelinia, RONDANI, *Atti. Soc. Ital. Sci., Milano*, 2: 290 (1860).

subaptera Felt

Hormomyia subeptera, FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 9 : 224 (1926)[1]. SENIOR-WHITE, *Cat. Indian Ins.*, 15: 6 (1928)[2]. FELT, *Lingnan Sci. J.*, 7 : 463 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 441 (1934); *ibid.*, 39 (3) : 284 (1937).

[1],[2]Nilgiris

calcuttaensis Mani

Hormomyia calcuttaensis, MANI, *Rec. Indian Mus.*, 39(3): 284 (1937)[1].

[1]Calcutta

ischaemi Felt

Oligotrophus ischaemi, KIEFFER, *Kew. Bull.*, 3: 71 (1910); *Gen. Ins.*, 152 : 50 (1913)[1]. BRUNETTI, *Rec. Indian Mus.*, 17:9, 271 (1920).

Hormomyia ischaemi, FELT, *Pusa Bull.*, 89 : 46-49, (1920)[2] [redescription]; *Mem. Dept. Agric. India, Ent. Ser.*, 7: 17 (1921)[3] [ex gall on *Inschaemum pilosum* Hack.]. Y. R. RAO, *Proc. V ent. Meet. Pusa*, p. 270-274 (notes) (1923)[4]. SENIOR-WHITE, *Cat. Indian Ins.*, 15: 6 (1928)[5]. FELT, *Lingnan Sci. J.*, 7: 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 441 (1934); *J. R. Asiatic Soc. Bengal, Sci*, 14 : 93,153 (1948)[6].

[1],[5]E. Indies
[2],[5]Coimbatore
[3]India
[4],[5]Ballary
[6]S. India

80. **Trishormomyia** Kieffer

Hormomyia (partim), KIEFFER, *Bull. Soc. Hist. Nat. Metz.*, 21: 26 (1901).

Trshormomyia, KIEFFER, *Neue, Gallmücken-Gallungen; Bitsch*, p. 2 (1912) [Genotype: *Trishormomyia strobli* Kieffer]; *Gen. Ins.*, 152 : 139, (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 169 (1925); *Lingnan Sci. J.*, 7 : 456 (1929). MANI, *Indian J. Ent.*, 7 (1&2): 225 (1946).

indica Mani,

Trishromomyia indica, MANI, *Rec. Indian Mus.*, 39 (3): 284 (1937)[1].

[1]Calcutta

pandani Felt

Trishormomyia pandani, FELT, *Treubia*, 1 : 270-271 (1921)[1] [ex gall on leaf of *Pandanus nitidus* Kunz.]; *Lingnan Sci. J.*, 7 : 463 (1929).

[1]Java

81. **Odontodiplosis** Felt

Cecidomyia (partim), FELT, *Rep.* 22 *N. Y. St. Mus.*, 110 : 141 (1907).

Odontodiplosis, FELT, *Bull. N. Y. St. Mus.*, 124 : 404 (1908) [Genotype: *Odontodiplosis karnerensis* Felt]. KIEFFER, *Gen. Ins.*, 152 : 203 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 171 (1925); *Lingnan Sci. J.*, 7 : 457. (1929). MANI, *Indian J. Ent.*, 7 (1 & 2) :226 (1945).

jonesi Nayar

Odontodiplosis jonesi, NAYAR, *Proc. R. ent. Soc. London*, (B) 18 (5-6) : 86 (1949)[1]. [1]Trivandrum

82. **Löwiola** Kieffer

Diplosis (partim), LÖW FRANZ, *Verh. Zool.-bot. Ges. Wien.*, 25 : 20 (1875).

Löwiola, KIEFFER, *Miscellanaa Ent.*, 5 : 5 (1896) [Genotype: *Lowiola centaureae* Löw]; *Gen. Ins.*, 152 : 206 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 15 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 175 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 13 (1928). FELT, *Lingnan Sci. J.*, 7 : 456 (1929). MANI, *Rec. Indian Mus.*, 36 (4) :442 (1934); *Indian J. Ent.*, 7 (1&2): 226 (1946).

costata Felt

Löwiola costata, FELT, *J. N. Y. ent. Soc.*, 23 : 182 (1912)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 15 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 13 (1928). FELT, *Lingnan Sci. J.*, 7 : 464 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 442 (1934)[4]. [1,2,3,4]Ceylon

83. **Tricontarinia** Kieffer

Tricontarinia, KIEFFER, *Bull. Laborat. Zool. Portici.*, 4 : 71 (1910) [Genotype: *Tricontarinia ciliatipennis* Kieffer]; *Gen. Ins.*, 152 : 145 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 171 (1925); *Lingnan Sci. J.*, 7 : 457 (1929). MANI, *Indian J. Ent.*, 7 (1 & 2): 226 (1946).

luzonensis Felt

Tricontarinia luzonensis, FELT, *Philipp. J. Sci.*, 13 : 281-325 (1918)[1] [ex gall on leaf of *Parashorea malaanonan*]; *Lingnan Sci., J.*, 7 : 464 (1929). [1]Philippines

84. **Pipaldiplosis** Mani

Pipaldiplosis, MANI, *Rec. Indian Mus.*, 37 (4) : 454 (1935) [Genotype: *Pipaldiplosis pipaldiplosis* Mani]; *Indian J. Ent.*, 4 (1) : 46 (1942); *ibid.*, 7 (1&2): 226 (1946).

pipaldiplosis Mani

Pipaldiplosis pipaldiplosis, MANI, *Indian J. Ent.*, 4(1) : 46 (1942)[1]. [ex gall No. 267 on leaf veins of *Ficus religiosa* Linn.]; *J. R. Asiatic Soc. Bengal*, 14 : 92,151 (1948)[2]. RAO, *Indian J. Ent.*, 11 (2) : 140 (1951)[3].

[1]Delhi
[2]Tanjore, Calcutta
Delhi Udaipur
[3]Agra

85. **Punarnavomyia** Mani

Cecidomyia (partim), MANI, *Indian J. Ent.*, 5: 161 (1943).

Punarnavomyia, MANI, *Indian J. Ent.*, 15 : 122 (1953) [Genotype: *Punarnavomyia boerhaaviaefoliae* (Mani)].

boerhaaviaefoliae (Mani)

Cecidomyia boerhaaviaefoliae, MANI, *Indian J. Ent.*, 15 : 122-125 (1953) [ex gall No. 255 on bud of *Boerhaavia* spp.][1]

[1]India

boerhaaviaefolae (Mani)

Cecidomyia boerhaaviaefolae, Mani *Indian J. Ent.*, 5:161 (1943)[1]. (ex gall No. 255 on *Boerhaassia repanda* Willd.).

[1]Delhi

Punarnavomya bocrkaaviefolae, Mani, *Indian J. Ent.*, 15 : 122-125 (1953)[2]. (ex gall No. 255 on leaf bud of *Boerhaavia diffusa* Linn.).

[2]Bharatpur State

86. **Chrysodiplosis** Kieffer

Chrysodiplosis, KIEFFER, *Trans. Linn. Soc. London*, 14:318 (1911) [Genotype: *Chrysodiplosis pulchericornis* Kieffer]; *Gen. Ins.*, 152 : 145 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 12 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 163 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 7 (1928). FELT, *Lingnan Sci., J.*, 7 : 450 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 430 (1934): *Indian J. Ent.*, 7 (1 & 2) : 219 (1946).

squamatipes Kieffer

Chrysodiplosis squamatipes, KIEFFER, *Spol. Zeyl.*, 8 : 28 (1912)[1]. BRUNETTI, *Rec. Indian Mus.*, 17: 12 (1920). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 7 (1928)[3]. FELT, *Lingnan Sci., J.*, 7 : 464 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 430 (1934).

[1,2,3]Peradeniya

87. **Arthrocnodax** Rübsaamen

Diplosis (partim), WINNETRZ, *Linnaea Ent. Stettin.*, 8 : 252 (1853).

Arthrocnodax, RUBSAAMEN, *W. ent. Z.*, 14 : 189 (1895) [Genotype: *Arthrocnodax vitis* Rübsaamen]. KIEFFER, *W. ent. Z.*, 15 : 92 (1896); *Synop. Cecid.*

Europ. Algerie, p. 29 (1897). FELT, *Bull. N. Y. St. Mus.*, 124 : 403 (1908); *J. N. Y. ent. Soc.*, 19 : 57 (1911). KIEFFER, *Gen. Ins.*, 152 : 155 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 12 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 163 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 8 (1928). FELT, *Lingnan Sci. J.*, 7 : 464 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 424 (1934); *Indian J. Ent.*, 7 (1&2): 220 (1946).

Endaphis, FELT, *Ent. News, Philadalphia*, 22 : 128-224 (1911) [Preocc.].

Feltodiplosis, KIEFFER, *Gen. Ins.*, 152 : 154 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 12 (1920).

walkeriana Felt

Arthrocnodax walkeriana, FELT, *J. N. Y. ent. Soc.*, 23 : 181 (1915)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 12 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 8 (1928). FELT, *Lingnan Sci. J.*, 7 : 464 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 425 (1934). — [1,2]Ceylon

rutherfordi Felt

Arthrocnodax rutherfordi, FELT, *J. N. Y. ent. Soc.*, 23: 108 (1915)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 12 (1920). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 8 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 465 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 425 (1934). — [1,2,3]Ceylon

coprae Felt

Arthrocnodax, coprae, FELT, *Philpp. J. Sci.*, 14 : 287-94 (1919)[1] [ex copra]; *Lingnan Sci. J.*, 7 : 465 (1929). — [1]Philippines

88. **Microdiplosis** Tavares

Microdiplosis, TAVARES, *Broteria*, 7 : 155 (1908) [Genotype: *Microdiplosis zambezensis* Tavares]. KIEFFER, *Gen. Ins.*, 152 : 210 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 163 (1925); *Lingnan Sci. J.*, 7 : 450 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 425 (1934); *Indian J. Ent.*, 7 (1 & 2) : 220 (1946).

pongamiae Mani

Microdiplosis pongamiae, MANI, *Rec. Indian Mus.*, 36 (4): 425 (1934)[1]. [ex gall on leaf of *Pongamia glabra* Vent.] — [1]Tanjore, Chilka-lake, Vellore, Calcutta, Madras

89. **Doxodiplosis** Kieffer

Stictodiplosis (partim), KIEFFER, *L'Ami des Sciences Nat.*, 1 : 9 *Fig.* 8 (1894); *et wien ent Z.*, 15 : 99 (1896).

Doxodiplosis, KIEFFER, *Neue Gallmücken-Gattungen Bitsch*, p. 1 (1912) [Genotype: *Doxodiplosis picridis* Kieffer]; *Gen. Ins.*, 152 : 244 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 164 (1925); *Lingnan Sci. J.*, 7 : 451 (1929). MANI, *Indian J. Ent.*, 7 (1&2): 220 (1946).

niveonigra Barnes

Doxodiplosis niveonigra, BARNES, *J. Fed. Malay St. Mus.*, 13 : 1-6 (1927)[1]; *Lingnan Sci. J.*, 7 : 465 (1929). [1]Siam

90. **Aschistonyx** Rübsaamen

Aschistonyx, RÜBSAAMEN, *Sitzungsb. Ges. Natuf. Freunde Berlin*, p. 66 (1917) [Genotype: *Aschistonyx carpinicolus* Rübsaamen]; *Ins. Tests. Zool. Rec.*, 5 : 66 (1919). FELT, *Bull. N. Y. St. Mus.*, 257 : 164 (1925); *Lingnan Sci. J.*, 7 : 451 (1929). MANI, *Indian J. Ent.*, 7 (1&2) : 220 (1946).

crataevae (Mani)

Cecidomyela crataevae, Mani, *Rec. Indian Mus.*, 36 (4): 42 (1934)[1]. (misspelt as *Cecidomyiella*) [ex gall No. 171 on leaf buds and leaves of *Crataeva religiosa* Förster]: *J. R. Asiatic. Soc. Bengal*, 14 : 93, 133 (1948)[2]. [1]Tanjore [2]Madras, [3,4]Agra

Aschistonyx crataevae, RAO *Rec. Indian Mus.*, 48 (3-4): 37-41, fig. 5, (1950)[3] [Redescription] MANI, *Agra Univ. J. Res.* (Sci), 2(2) : 248, pl. vi (1953)[4].

91. **Moreschiella** Del Guercio

Mareschiella, Del GUERCIO, *Agric. Colon.*, 12 : 345-369 (1918) [Genotype: *Moreschiella morindla* De. Gr.]. FELT, *Bull. N. Y. St. Mus.*, 257 : 164 (1925); *Lingnan Sci. J.*, 7 : 451 (1929).

erecta Nayar

Moreschiella erecta, NAYAR, *Proc. R. Ent. Soc. London*, (B) 18 (5-6) : 88 (1949)[1]. [1]Trivandrum

92. **Plutodiplosis** Kieffer

Plutodiplosis, KIEFFER, *Spol. Zeyl.*, 8 : 27 (1912) [Genotype: *Plutodiplosis magnifica* Kieffer]; *Gen. Ins.*, 152: 166 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 12 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 164 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 9 (1928). FELT, *Lingnan Sci. J.*, 7 : 430 (1929).

Mani, *Rec. Indian Mus.*, 36 (4) : 430 (1934); *Indian J. Ent.*, 7 (1&2): 220 (1946).

magnifica Kieffer

Plutodiplosis magnifica, Kieffer, *Spol. Zeyl.*, 8 : 27 (1912)[1]; *Gen. Ins.*, 152 : 166 (1913)[1]. Brunetti, *Rec. Indian Mus.*, 17 : 12 (1920)[2]. Senior-White, *Cat. Indian Ins.*, 15 : 9 (1928)[3]. Felt, *Lingnan Sci. J.*, 465 (1929). Mani, *Rec. Indian Mus.*, 36 (4): 430 (1934).

[1,2,3]Peradeniya
Ceylon

93. **Thorodiplosis** Felt

Thorodiplosis, Felt, *Treubia*, 2 : 89 (1921) [Genotype: *Thorodiplosis impatientis* Felt]; *Bull. N. Y. St. Mus.*, 257 : 165 (1925); *Lingnan Sci. J.*, 7 : 462 (1929). Mani, *Indian J. Ent.*, 7 (1&2) : 221 (1946).

impatientis Felt

Thorodiplosis impatientis, Felt, *Treubia*, 2 : 89-94 (1921)[1]. [ex gall on *Impatiens platypetala* Lindl.]; *Lingnan Sci. J.*, 7 : 465 (1929).

[1]Java

94. **Raodiplosis** Felt

Raodiplosis, Felt, *Mem. Dept. Agric. India, Ent. Ser.* 7 : 6 (1920) [Genotype: *Raodiplosis orientalis* Felt]; *Bull. N. Y. St. Mus.*, 257 : 165 (1925). Senior-White, *Cat. Indian Ins.*, 15 : 14 (1928). Felt, *Lingnan Sci. J.*, 7 : 452 (1929). Mani, *Rec. Indian Mus.*, 36 (4): 430 (1934); *Indian J. Ent.*, 7 (1 & 2): 221 (1946).

orientalis Felt

Raodiplosis orientalis, Felt, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 7 (1920)[1]. Senior-White, *Cat. Indian Ins.*, 15 : 14 (1928). Felt, *Lingnan Sci. J.*, 7 : 465 (1929). Mani, *Rec. Indian Mus.*, 38 (2) : 195 (1936)[2] ; *ibid.*, 40 (4) : 336 (1938).

[1]Burma
[2]Coimbatore

95. **Macrodiplosis** Kieffer

Diplosis (partim), Fr. Löw, *Verh. Zool. bot. Ges. Wien.*, 27 : 14 (1877).

Cecidomyia (partim), Liebel, *Zeitschr, f Naturwiss.*, 59 : 563 (1886).

Macrodiplosis, Kieffer, *Bull. Soc. Ent., France*, 64 : 194 (1895) [Genotype: *Macrodiplosis dryobia* (F. Löw)]; *Gen. Ins.*, 152 : 222 (1913). Felt, *Bull. N. Y. St. Mus.*, 257 : 165 (1925); *Lingnan Sci. J.*, 7 : 452

(1929). MANI, *Indian J. Ent.*, 7 (1&2): 222 (1946). RAO, *Rec. Indian Mus.*, 50 : 314 (1952).

visvanathi Rao

Macrodiplosis visvanathi, Rao, *Rec. Indian Mus.*, 50: 314-317, fig. 5 (1952)[1]. [1]Dehra Dun

96. **Androdiplosis** Felt

Androdiplosis, FELT, *J. N. Y. ent. Soc.*, 23 : 182 (1915) [Genotype: *Androdiplosis coccidivora* Felt]. BRUNETTI, *Rec. Indian Mus.*, 17 : 16 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 165 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 15 (1928). FELT, *Lingnan Sci. J.*, 7 : 452 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 431 (1934).

coccidivora Felt

Androdiplosis coccidivora, FELT, *J. N. Y. ent. Soc.*, 23: 183 (1915)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 16 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 15 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 431 (1934). [1,2,3]Ceylon

97. **Diplecus** Kieffer

Coprodiplosis (partim), KIEFFER, *Spol. Zeyl.*, 8 : 29 (1912).

Diplecus, KIEFFER, *Bull. Soc. Hist. Nat. Metz.*, 28 : 55 (1913) [Genotype: *Diplecus inconspicuous* Kieffer]; *Gen. Ins.*, 152 : 210 (1913). BRUNETTI, *Rec. Indian Mus.*, 17 : 14 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 165 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 11 (1928). FELT, *Lingnan Sci. J.*, 7 : 452 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 431 (1934).

inconspicuous Kieffer

Copodiplosis inconspicuous, KIEFFER, *Spol. Zeyl.*, 8 : 29 (1912)[1]. [1,3,4]Peradeniya [2,4]Ceylon

Diplecus inconspicuous, KIEFFER, *Gen. Ins.*, 152 : 201 (1913)[2] *Bull. Nat. Hist. Metz.*, 27 : 55 (1913). BRUNETTI; *Rec. Indian Mus.*, 17 : 14 (1920)[3]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 11 (1928)[4]. FELT, *Lingnan Sci, J.*, 7 : 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 431 (1934)[5].

98. **Charidiplosis** Tavares

Charidiplosis, TAVARES, *Broteria*, 16 : 80 (1918) [Genotype: *Charidilosis concinna* Tavares]. FELT, *Bull. N. Y. St. Mus.*, 257 : 166 (1925); *Lingnan Sci. J.*, 7 : 453

(1929). MANI, *Indian J. Ent.*, 7 (1&2) : 221 (1946). RAO, *Rec. Indian Mus.*, 50: 310, (1952).

indica Rao

Charidiplosis indica, RAO, *Rec. Indian Mus.*, 50 : 312 (1952)[1]. [1]Agra

99. **Octodiplosis** Girad

Diplosis (partim), RÜBSAAMEN, *W. ent. Z.*, 14 : 184 (1895).

Octodiplosis, GIRAD, *Bull. Soc. Ent. France*, 63 : 161 (1994) [Genotype: *Octodiplosis glyceriae* Rübsaamen]. KIEFFER, *Gen. Ins.*, 152 : 231 (1913). FELT, *Bull. N. Y. St. Mus.*, : 165 (1925); *Lingnan Sci. J.*, 7 : 453 (1929). MANI, *Indian J. Ent.*, 7 (1&2): 222 (1945).

fungivora Nayar

Octodiplosis fungivora, NAYAR, *Proc. R. ent. Soc.*, London, (B) 18 (5-6) : 89 (1949)[1] [1]Trivandrum

100. **Diplodontomyia** Rao

Diplodontomyia, RAO, *Indian J. Ent.*, 11 (2) : 120 (1951) [Genotype: *Diplodontomyia orientalis* Rao].

orientalis Rao

Diplodontomyia orientalis, RAO, *Indian J. Ent.*, 11 (2) : 121 (1951)[1]; *Rec. Indian Mus.*, 50 : 310 (1952)[2]. [1,2]Agra

deepica Rao

Diplodontomyia deepica, RAO, *Rec. Indian Mus.*, 50 : 310-312, fig. 3 (1952)[1]. [1]Agra

101. **Hyperdiplosis** Felt

Cecidomyia (partim), FELT, *Rep.* 22 *N. Y. St. Mus.*, 110 : 136 (1907).

Hyperdiplosis, FELT, *Bull. N. Y. St. Mus.*, 124 : 405 (1908) [Genotype: *Hyperdiplosis lobata* Felt]. KIEFFER, *Gen. Ins.*, 152 : 211 (1913). MANI, *Indian J. Ent.*, 7 (1&2) : 222 (1945).

banksi Felt

Hyperdiplosis banksi, FELT, *Philipp. J. Sci.*, 13 : 281-325 (1918)[1]. [ex gall on leaf of *Cissus adnata* Wall.]; *Mem. Dept. Agric. India, Ent. Ser.*, 9 : 241-245 (1926)[2]; *Lingnan Sci. J.*, 7 : 463 (1929)[3]. [1,3]Philippines [2,3]E. Indies

relicta Felt

Hyperdiplosis relicta, FELT, *Philipp. J. Sci.*, 13 : 281-325 (1918)[1]; *Lingnan Sci. J.*, 7 : 463 (1929)[2]. [1,2]Philippines

102. **Lestodiplosis** Kieffer

Cecidomyia (partim), Macquart, *Recueil Soc. Sci. Agricult. Lille*, p. 171 (1826).

Diplosis (partim), H. Löw, *Dipt. Beschr.*, 4 : 32 (1850).

Lestodiplosis, Kieffer, *Bull. Soc. Ent. France*, 63 :28 (1894) [Genotype: *Lestodiplosis alternana* Kieffer]. Felt, *Bull. N. Y. St. Mus.*, 124 : 407 (1908). Rübsaamen, *Zeit. Wissen Insektenbiol*, 15 : 285 (1910). Felt, *J. N. Y. ent. Soc.*, 19 : 59 (1911). Kieffer, *Gen. Ins.*, 152 : 195 (1913). Brunetti, *Rec. Indian Mus.*, 17:14 (1920). Felt, *Bull. N. Y. St. Mus.*, 257 : 167 (1925). Senior-White, *Cat. Indian Ins.*, 15:11 (1928). Felt, *Lingnan Sci. J.*, 7 : 454 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 432 (1934); *Indian J. Ent.*, 7 (1&2) : 222 (1946).

Coprodiplosis, Kieffer, *Fuelle Jennes Nat.*, 24:84 (1894).

Hemidiplosis, Kieffer, *Ann. Soc. Nat.*, 1 : 9 (1894).

ceylanicus Kieffer

Lestodiplosis ceylanicus, Kieffer, *Spol. Zeyl.*, 8 : 28 (1912)[1]. Brunetti, *Rec. Indian Mus.*, 17 : 14 (1920)[2]. Senior-White, *Cat. Indian Ins.*, 15 : 11 (1928)[3]. Mani, *Rec. Indian Mus.*, 36 (4):433 (1934).

[1,2,3]Paradeniya

103. **Orseoliella** Kieffer

Orseolia (partim), Kieffer, *Marcellia*, 8 : 125 (1909).

Orseoliella, Kieffer, *Marcellia*, 11 :231 (1912) [Genotype: *Orseoliella javanica* Kieffer]; *Gen. Ins.*, 152 : 152 (1913). Brunetti, *Rec. Indian Mus.*, 17 : 15 (1920). Felt, *Bull. N. Y. St. Mus.*, 257:167 (1925). Senior-White, *Cat. Indian Ins.*, 15 : 7 (1928). Felt, *Lingnan Sci. J.*, 7 : 453 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 432 (1934); *Indian J. Ent.*, 7 (1&2) : 222 (1946); *Bull. ent. Res.*, 38 (3) : 444 (1947).

apludae Felt

Orseoliella apludae, Felt, *Mem. Dept. Agric. Ent. Ser.*, 7 : 8 (1920)[1] [ex gall on *Apluda varia* Hack. *A. mutica*], *Mem. Dept., Agric. Ent. Ser.*, 7 : 16 (1921)[2]. Y. R. Rao, *Proc. V ent. Meet. Pusa*, p. 272 (1923)[3]. Senior-White, *Cat. Indian Ins.*, 15 : 7 (1928)[4]. Felt, *Lingnan Sci. J.*, 7 : 463 (1929)[5]. Mani, *Rec. Indian Mus.*, 36 (4) : 432 (1934); *ibid.*, 40

[1,2,4,5,6]Coimbatore
[3,4,5]S. India
[7]Java & India

(4):336 (1938)[6]; *Bull. ent. Res.*, 38 (3): 445 (1947); *J. R. Asiatic Soc. Bengal*, 14: 93, 153 (1948)[7].

bengalensis Mani

Orseoliella bengalensis, MANI, *Rec. Indian Mus.*, 39 (3); 285 (1937)[1]; *Bull. ent. Res.*, 38 (3): 445 (1947).

[1]Calcutta

graminis Felt

Orseoliella graminis, FELT, *Mem. Dept., Agric. India, Ent., Ser.*, : 16, 22 (1921)[1] [ex gall on *Andropogon squarrosus* Hack.]. Y. R. RAO, *Proc. V ent. Meet. Pusa*, p. 272 (1923)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 8 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 463 (1929). MANI, *Rec. Indian Mus.*, 36 (4): 432 (1934); *Bull. ent. Res.*, 38 (3): 445 (1947); *J. R. Asiatic Soc. Bengal*, 14 : 93, 152 (1948)[4].

[1,2,4]Kistna Dt.
[3]S. India

ischaemi Mani

Orseoliella ischaemi, MANI, *Bull. ent. Res.*, 38 (3) : 445 (1947)[1]. [ex gall on *Ischaemum ciliare* Retz.]; *J. R. Asiatic Soc. Bengal*, 14 : 93, 153 (1948)[2].

[1,2]Coimbatore

javanica Kieffer

Orseolia javanica, KIEFFER, *Marcellia*, 8 : 225 (1909)[1].

Orseoliella javanica, KIEFFER, *Marcellia*, 11 : 231 (1912); *Gen. Ins.*, 152 : 152 (1913)[2]. FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 17 (1921)[4] [ex gall on *Imperata cylindrica* Beauv.]. Y. R. RAO, *Proc. V ent. Meet. Pusa*, 272 (1923)[7]. FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 9 : 241 (1926)[5]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 8 (1928). FELT, *Lingnan Sci. J.*, 7 : 463 (1929). MANI, *Bull. ent. Res.*, 38 (3) : 445 (1947); *J. R. Asiatic Soc. Bengal*, 14 : 93 (1948)[6].

[1,2,3,6]Java
[4,7]Kistna Dt.
[5]E. Indies
[6]Calcutta

orientalis Felt

Orseoliella orientalis. FELT, *Treubia*, 2 : 89-92 (1921)[1] [ex gall on *Oplismenus compobitus*]; *Lingnan Sci. J.*, 7 : 463 (1929).

[1]Java

104. **Xylodiplosis** Kieffer

Cecidomyia (partim), ZETTERSTEDT, *Ditp. scandinav.*, 9: 3683 (1850).

Diplosis (Partim), WINNERTS, *Linn. ent. Stett.* 8 : 276 (1853).

Xylodiplosis, KIEFFER, *Bull. Soc. Ent. France*, 64 : 193 (1895) [Genotype: *Xylodiplosis praecox* (Winnertz)]; *Gen. Ins.*, 152 : 226 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 169 (1925); *Lingnan Sci. J.*, 7 : 455 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 438 (1934); *Indian J. Ent.*, 7 (1&2) : 223 (1946).

kempi Mani

Xylodiplosis kempi, MANI, *Rec. Indian Mus.*, 36 (4): 438 (1944)[1].

[1]North Kanara

105. **Parallelodiplosis** Rübsaamen

Diplosis (partim), FR. LÖW, *Verh. Zool. bot., Ges. Wien.*, 39 : 202 (1889).

Clinodiplosis (partim), KIEFFER, *Synopse des Cecidomyies d'Europe et d'Algerie*, p. 38 (1898).

Parallelodiplosis, RÜBSAAMEN, *Zeitsch. Wiss. Insektenbiol.* 6 : 287 (1910) [Genotype: *Parallelodiplosis gallipuda* (Löw)]. KIEFFER, *Gen. Ins.*, 152 : 228 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 168 (1925); *Lingnan Sci. J.*, 7 : 454 (1929). MANI, *Indian J. Ent.*, 7 (1&2): 224 (1946).

javanica Felt

Parallelodiplosis javanica, FELT, *Treubia*, 2 : 89-92 (1921)[1] [ex gall on *Saccolopis indica* (*Panicum indicum* Linn.)]; *Lingnan Sci. J.*, 7 : 463 (1929)[2]. MANI, *Bull. ent. Res.*, 38 (3) : 447 (1947)3; *J. R. Asiatic Soc. Bengal*, 14 : 93 (1948)[4].

[1,2]Java
[3,4]Calcutta

paspali Felt

Parallelodiplosis paspali, FELT, *Treubia*, 2 : 89-92 (1921)[1] [ex gall on *Paspalum sirobiculatum* Linn.]; *Lingnan Sci. J.*, 7 : 463 (1929)[2]. MANI, *J. R. Asiatic Soc. Bengal*, 14 : 93, 153 (1948)[3].

[1,2,3]Java
[3]S. India

106. **Hypodiplosis** Kieffer

Clinodiplosis (partim), KIEFFER & LEEUWEN, *Marcellia*, 8 : 129 (1909).

Hypodiplosis, KIEFFER, *Gen. Ins.*, 152 : 187 (1913) [Genotype: *Hypodiplosis paederiae* (K& L)]. FELT, *Bull. N. Y. St. Mus.*, 257 : 168 (1925); *Lingnan Sci. J.*, 7 : 454 (1929). MANI, *Indian J. Ent.*, 7 (1&2) : 224 (1946).

paederiae (Kieffer & Van Leeuwen)

Clinodiplosis paederiae, KIEFFER & VAN LEEUWEN, *Marcellia*, 8 : 129 (1990)[1].

Hypodiplosis paederiae, KIEFFER, *Gen. Ins.*, 152 : 187 (1913). FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 9 : 241-245 (1926)[2]; *Lingnan Sci, J.*, 7 : 463 (1929)[3].

[1]Java
[2,3]E. Indies

107. **Pachydiplosis** Kieffer

Pachydiplosis, KIEFFER, *Bul. Nat. Hist. Soc. Metz.*, 28 : 108 (1913) [Genotype: *Pachydiplosis africanus* Kieffer];

Gen. Ins., 152 : 224 (1913). Brunetti, *Rec. Indian Mus.*, 17 : 15 (1920). Felt, *Bull. N. Y. St. Mus.*, 257 : 169 (1925). Senior-White, *Cat. Indian Ins.*, 15 : 14 (1928). Felt, *Lingnan Sci. J.*, 7 : 455 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 433 (1934); *Indian J. Ent.*, 7 (1&2) : 225 (1946).

ceylanicus Kieffer

Clinodiplosis ceylanicus, Kieffer, *Spol. Zeyl.*, 8: 26-27 (1912)[1].

Pachydiplosis ceylanicus, Kieffer, *Gen. Ins.*, 152 : 224 (1913)[2]. Brunetti, *Rec. Indian Mus.*, 17 : 16 (1920). Senior-White, *Cat. Indian Ins.*, 15 : 14 (1928). Felt, *Lingnan Sci. J.*, 7 : 463 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 437 (1934).

[1,2,4]Ceylon
[4,4]Pusa

graminicola (Kieffer & Massalongo)

Clinodiplosis graminicloa, Kieffer & Massalongo, *Marcellia*, 8 : 127 (1909)[1].

Pachydiplosis graminicola, Kieffer, *Gen. Ins.*, 152 : 224 (1913)[2]. Brunetti, *Rec. Indian Mus.*, 17 : 16 (1920). Felt, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 16 (1921)[3]. Y. R. Rao, *Proc. V ent. Meet. Pusa*, p. 272 (1923)[4]. Senior-White, *Cat. Indian Ins.*, 15 : 14 (1928). Mani, *J. R. Asiatic Soc. Bengal*, 14 : 93 (1948)[5] [ex gall on *Cynodon dactylon* Pers.]

[1,2,3]Java
[4,5]Kistna Dt.

oryzae Mani

Cecidomyia oryzae, Wood-Mason in Riley, *Amer. Naturalist*, p. 149 (1881). [Sans description]. Cotes, *Indian Mus., Notes.* 1 : 103 (1890). Vander Wulp, *Cat. Dipt. S. Asia*, p. 29 (1896). Howlett, *Indian Insect life*, p. 581 (1909). Kert, *Cat. Dipt.*, 2:115 (1909)[2]. Kieffer, *Gen. Ins.*, 152 : 217 (1913)[3].

Pachydiplosis oryzae, Felt, *Mem. Dept. Agric. India, Ent. Ser.*, 7 : 16 (1921)[4] [ex gall on *Ophiurus corimbosus*, *Oryza sativa*, *Panicum stagninum*]. Brunetti, *Rec. Indian Mus.*, 17 : 16 (1920)[5]. Rao, *Proc. V ent. Meet. Pusa*, p. 270 (1923). Senior-White, *Cat. Indian Ins.*, 15 : 14 (1928). Mani, *Rec. Indian Mus.*, 36 (4); 433 (1934); [Sp. first described]; *ibid.*, 40: (4) : 336 (1938); *J. R. Asiatic Soc. Bengal*, 14 : 93, 153 (1948), [ex galls of *Oryza*].

[1]Monghyr
[2]E. India
[2,3,6]Bengal
[4]Kistna Dt.
[5]Cuttack
[6]Ranchi, Coimbatore, Tanjore, Malayam, Java, Formosa

108. **Itonida** Meigen

Itonida, MEIGEN, *Nouvelle Classification des mouches a deux ailes* (*Diptera* Linnaeus], *Paris,* p. 19 (1800). HANDEL, *Verhandl, Zool.-bot. Ges. Wien.,* 58 : 49 (1908). FELT, *J. N. Y. ent. Soc.,* 19 : 61 (1911). KIEFFER, *Gen. Ins.,* 152 : 258 (1913). FELT, *Bull. N. Y. St. Mus.,* 231-232 : 175-208 (1921); *ibid.,* 257 : 169 (1925). SENIOR-WHITE, *Cat. Indian Ins.,* 15 : 17 (1928). FELT, *Lingnan Sci. J.,* 7 : 455 (1929). MANI, *Rec. Indian Mus.,* 36 (4) : 437 (1934); *Indian J. Ent.,* 7 (1&2) : 225 (1946).

Cecidomyia, MEIGEN, *Illeger's Mag.,* 2 : 261 (1803). FELT, *Bull. N. Y. St. Mus.,* 124 : 412 (1908). RUBSAAMEN, *Zeit. Wiss. Insekt,* 15 : 286 (1910). KIEFFER, *Gen. Ins.,* 152 : 211 (1913). BRUNETTI, *Rec. Indian Mus.,* 17 : 15 (1920). SENIOR-WHITE, *Cat. Indian Ins.,* 15 : 13 (1921).

Diplosis, H. LÖW, *Dipt. Beitr.,* 4 : 209 (1850). OSTEN SACKEN, *Mon. N. Amer. Diptera,* 1 : 76 (1862). KIEFFER, *Synop. Cecid. Europe Algerie,* p. 41 (1897).

Cryptodiplosis, KIEFFER, *Bull. Soc. Ent. France,* 64 : 194 (1895).

paederiae Felt

Itonida paederiae, FELT, *Philipp. J. Sci.,* 14 : 287-294 (1919)[1]. [ex gall on leaf of *Paederia tomentosa* Blume]; *Mem. Dept. Agric. India, Ent, Ser.,* 9 : 241-245 (1926)[2] *Lingnan Sci. J.,* 7 : 463 (1929)[3].

[1,2,3]Philippines

paspalumi Mani

Itonida paspalumi, MANI, *Rec. Indian Mus.,* 38 (2) : 196 (1936)[1]. [ex gall on *Paspalum scrobiculatum.* Linn.]; *J. R. Asiatic Soc. Bengal,* 14 : 93,153 (1948)[2]

[1,2]S. India

penniseti Felt

Itonida penniseti, FELT, *Mem. Dept. Agric. India, Ent. Ser.,* 7 : 9 (1920)[1]; *ibid.,* 11 : 17 (1921)[2] [ex gall on *Pennisetum alopecuros* Rich]. SENIOR-WHITE, *Cat. Indian Ins.,* 15 : 17 (1928)[3]. FELT, *Lingnan Sci. J.,* 7 : 463 (1929). MANI, *Rec. Indian Mus.,* 36 (4) : 438 (1934)[4]; *J. R. Asiatic Soc. Bengal,* 14 : 93, 153 (1948)[5].

[1,2]Coimbatore
[3]India
[4]Tanjore
[5] S. India

seminis Felt

Itonida seminis, FELT, *Mem. Dept. Agric. India Ent. Ser.,* 7 : 26 (1921)[1] [ex gall on ear heads of, *Pennisetum typhoideum* Gertu.]. SENIOR-WHITE, *Cat. Indian Ins.,* 15 : 17 (1928)[2]. MANI, *Rec. Indian Mus.,* 36 (4) 438 (1934); *J. R. Asiatic Soc. Bengal,* 14 : 93, 153 (1948)[3].

[1,2]Coimbatore

109. **Schizobremia** Felt

Schizobremia, FELT, *Ent. Mon. Mag., London*, 62: 183 (1926) [Genotype: *Schizobremia formosana* Felt]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 16 (1928). FELT, *Lingnan Sci. J.*, 7 : 450 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 423 (1934); *Indian J. Ent.*, 7 : 215 (1946).

bangalorensis Rao

Schizobremia bangalorensis, RAO, *Proc. R. ent. Soc., London*, (B) 21 (3-4): 54-55 (1952)[1]. (ex *Pseudococcus* sp.).

[1]Bangalore

malabarensis Felt

Schizobremia malabarensis, FELT, *Mem. Dept. Agric. India, Ent. Ser.*, 10 : 1-2 (1927)[1] [reared from *Pseudococcus virgatus*]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 16 (1928)[2]. FELT, *Lingnan Sci. J.*, 7 : 465 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 424 (1934)[3].

[1,2]Taliparamba
[3]South India.

110. **Xiphodiplosia** Felt

Xiphodiplosis, FELT, *J. N. Y. ent. Soc.*, 23 : 180 (1915) [Genotype: *Xiphodiplosis fulva* Felt]. BRUNETTI, *Rec. Indian Mus.*, 17 : 16 (1920). FELT, *Bull. N. Y. St. Mus.*, 257 : 162 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 17 (1928). FELT, *Lingnan Sci. J.*, 7 : 450 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 424 (1934); *Indian J. Ent.*, 7 (1&2) : 216 (1946).

fulva Felt

Xiphodiplosis fulva, FELT, *J. N. Y. ent. Soc.*, 23 :(180) (1915)[1]. BRUNETTI, *Rec. Indian Mus.*, 17 : 16 (1920)[2]. SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 17 (1928)[3]. FELT, *Lingnan Sci. J.*, 7 : 465 (1929).

[1,2,3]Ceylon.

111. **Diadiplosis** Felt

Diadiplosis, FELT, *J. N. Y. ent. Soc.*, 19 : 54 (1911) [Genotype: *Diadiplosis cocci* Felt]. KIEFFER, *Gen. Ins.*, 152 : 240 (1913). FELT, *Bull. N. Y. St. Mus.*, 202 : 240 (1918). BRUNETTI, *Rec. Indian Mus.*, 17 : 14 (1920). FELT, *Bull. N. Y. St. Mus.*, 256: 162 (1925). SENIOR-WHITE, *Cat. Indian Ins.*, 15 : 16 (1928). FELT, *Lingnan Sci. J.*, 7 : 450 (1929). MANI, *Rec. Indian Mus.*, 36 (4) : 424 (1934); *Indian J. Ent.*, 7 (1&2) : 216 (1946).

coccidivora Felt

Diadiplosis coccidivora, Felt, *Ent. News*. 47 : 86 (1914)[1]. Brunetti, *Rec. Indian Mus.*, 17 : 14 (1920)[2]. Senior-White, *Cat. Indian Ins.*, 15 : 16 (1928). Felt, *Lingnan Sci., J.*, 7 : 465 (1929)[4]. Mani, *Rec. Indian Mus.*, 36 (4) : 424 (1934)[5]. [1,2,3,4,5]Ceylon

indica Felt

Diadplosis indica, Felt, *Mem. Dept. Agric. India Ent. Ser.*, 7 : 6 (1920)[1] [preying on *Pseudococcus* and *Phenacoccus*]. Senior-White, *Cat. Indian Ins.*, 15 : 16 (1928)[2]. Felt, *Lingnan Sci: J.*, 7 : 465 (192). Mani, *Rec. Indian Mus.*, 36 (4) : 424 (1934); *ibid.* 40 (4) : 336 (1938)[4]. [1,2,3,4]Pusa

112. **Clinodiplosis** Kieffer

Cecidomyia (partim), Walker, *Ins. Britannica*, 3 : 110 (1856).

Diplosis, Kieffer, *Ent. Nachr. Berlin*, 15 : 152 (1889).

Clinodiplosis, Kieffer, *Feuille Jeune Natur*, 24 : 121 (1894) [Genotype: *Clinodiplosis cilicrus* Kieffer]. Winnertz, *W. Ent. Z.*, 15 : 93, 96 (1896). Felt, *J. N. Y. ent. Soc.*, 19 : 54 (1911). Kieffer, *Gen. Ins.*, 152 : 237 (1913). Felt, *Bull. N. Y. St. Mus.*, 202 : 177 (1918). Brunetti, *Rec. Indian Mus.*, 17 : 16 (1920). Felt, *Bull. N. Y. St. Mus.*, 257 : 162 (1925). Senior-White, *Cat. Indian Ins.*, 15 : 15 (1928). Felt, *Lingnan Sci. J.*, 7 : 449 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 422 (1934); *Indian J. Ent.*, 7 (1&2):215 (1946).

artemisiarum Kieffer

Clinodiplosis artemisiarum, Kieffer, *Marcellia*, 7 : 156 (1908) from larvae; *Gen. Ins.*, 152 : 237 (1913)[1]. Brunetti *Rec. Indian Mus.*, 17 : 16 (1920)[2]. Senior-white, *Cat. Indian Ins.*, 15 : 15 (1928). Felt, *Lingnan Sci. J.*, 7 : 464 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 422 (1934); *J. R. Asiatic. Soc. Bengal*, 14 : 93 (1948)[3] [ex gall No. 229 on stem of *Artemisia sp.*]. [1,2]E. Indies [3]Kurseong

cellularis Kieffer

Clinodiplosis cellularis, Kieffer, *Marcellia*, 7 : 156 (1908)[1] (from larvae); *Gen. Ins.*, 152 : 238 (1913). Brunetti, *Rec. Indian Mus.*, 17 : 16 (1920)[2]. Senior-White, *Cat. Indian Ins.*, 15 : 15 (1928). Felt, *Lingnan Sci. J.*, 7 : 464 (1929). Mani, *Rec. Indian Mu* 36 (4) : 422 (1934); *J. R. Asiatic* [1]India

Soc. Bengal, 14 : 93 (1948)[3] [ex gall on unidentified plant].

nodifex Kieffer

Clinodiplosis nodifex, Kieffer, *Marcellia*, 7 :155 (1908)[1] (from larvae); *Gen. Ins.*, 152 : 238 (1918). Brunetti, *Rec. Indian Mus.*, 17 : 16 (1920)[2]. Senior-White, *Cat. Indian Ins.*, 15 : 15 (1928). Felt, *Lingnan Sci. J.*, 7 : 464 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 422 (1934); *J. R. Asiatic Soc., Bengal*, 14 : 93, 150 (1948)[3] [ex gall No. 261 on stem of *Cyclostomon assamicus* Hook.]. [1]India

paederiae Kieffer

Cnlinodiplosis paederiae, Kieffer, *Marcellia*, 8 : 129-131 (1900)[1]. Felt, *Lingnan Sci. J.*, 7 : 464 (1929). [1]Java

113. **Oribremia** Kieffer

Oribremia, Kieffer, *Rec. Indian Mus.*, 9 : 199 (1913) [Genotype: *Oribremia mutifida* Kieffer]; *Gen. Ins.*, 152: 194 (1913). Brunetti, *Rec. Indian Mus.*, 17 : 14 (1920). Felt, *Bull. N. Y. St. Mus.*, 257 : 162 (1925). Senior-White, *Cat. Indian Ins.*, 15 : 11 (1928). Felt, *Lingnan Sci. J.*, 7 : 449 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 422 (1934); *Indian J. Ent.*, 7 (1&2) : 215 (1946).

multifida Kieffer

Oribremia multifida, Kieffer, *Rec. Indian Mus.*, 9 : 199 (1913)[1]; *Gen. Ins.*, 152 : 194 (1913)[2]. Brunetti, *Rec. Indian Mus.*, 17 : 14 (1920)[3]. Senior-White, *Cat. Indian Ins.*, 15 : 11 (1928)[4]. Felt, *Lingnan Sci, J.*, 7 : 464 (1929). Mani, *Rec. Indian Mus.*, 36 (4) : 423 (1934)[5]. [1,2,4,5]Himalayas [3,4]Bhowali

114. **Profeltiella** Kieffer

Lestodiplosis (partim), Kieffer, *Bull. Soc. Hist. Nat. Metz.*, 26 : 25 (1909).

Profeltiella, Kieffer, *Neue Gallmucken Gattungen, Bitsch*, p. 2 (1912) [Genotype: *Profeltiella ranunculi* Kieffer]; *Gen. Ins.*, 152 : 194 (1913). Felt, *Bull. N. Y. St. Mus.*, 157 : 162 (1925); *Lingnan Sci. J.*, 7 : 449 (1929). Mani, *Indian J. Ent.*, : 215 (1946).

orientalis Felt

Profeltiella orientalis, Felt, *Philip. J. Sci.*, 13 : 138, 281 (1918)[1]. [ex gall on leaf of *Siphonodon celastrineus* Griff.]; *Lingnan Sci. J.*, 7 : 464 (1929). [1]Philippines

115. **Mycodiplosis** Rübsaamen

Diplosis (partim), WINNERTZ, *Linnaea Ent. Stettin,* 8 : 267 (1853).

Cecidomyia (partim), WALKER, *Ins. Britannica Dipt.,* 3 : 111 (1856).

Mycodiplosis, RÜBSAAMEN, *Ent. Nachr. Berlin,* 21 : 186 (1895) [Genotype : *Mycodiplosis coniophaga* (Winnertz)]. KIEFFER, *W. Ent. Z.,* 15 : 92 (1856); *Synop. Cecid. Europ Algerie,* p. 28 (1897). FELT, *Bull. N. Y. St. Mus.,* 124 : 400 (1908). RUBSAAMEN, *Zeit. Wissenschaft Insektenbiol.,* 15: 289 (1909). FELT, *J. N. Y. ent. Soc.,* 19:54 (1911). KIEFFER, *Gen. Ins.,* 152 : 241 (1913). FELT, *Bull. N. Y. St. Mus.,* 202 : 179 (1918). BRUNETTI, *Rec. Indian Mus.,* 17 : 16 (1920). FELT, *Bull. N. Y. St. Mus.,* 257 : 162 (1925). SENIOR-WHITE, *Cat. Indian Ins.,* 15 : 16 (1928). FELT, *Lingnan Sci. J.,* 7 : 449 (1929). MANI, *Rec. Indian Mus.,* 36 (4): 423 (1934); *Indian J. Ent.,* 7 (1&2) : 215 (1946).

indica Felt

Mycodiplosis indica, FELT, *Mem. Dept. Agric. India, Ent. Ser.,* 7 : 5 (1920)[1] [ex larvae feeding on rust spores on *Pennisetum typhoideum* Gertu.]; *ibid.,* 7 : 171 (1921). SENIOR-WHITE, *Cat. Indian Ins.,* 15 : 16 (1928)[2]. FELT, *Lingnan Sci. J.,* 7: 464 (1929). MANI, *Rec. Indian Mus.,* 36 (4): 423 (1934)[3]; *ibid.,* 38 (2) : 195 (1936)[4] [ex rust spores on leaves of *Lucerna*].

[1,2,4]Coimbatore
[3]Tanjore

spondiasi Felt

Mycodiplosis spondiasi, FELT, *Philipp. J. Sci.,* 17 : 231 (1920)[1] [ex gall on *Spondias mombin*]; *Lingnan Sci. J.,* 7:465 (1929).

[1]Philippines

116. **Gynodiplosis** Felt

Gynodiplosis, FELT, *Treubia,* 9 : 383 (1927) [Genotype: *Gynodiplosis humata* Felt].

humata Felt

Gynodiplosis humata, FELT, *Treubia,* 9 : 383 (1927)[1]. [ex gall on *Humata alpina* Moore]; *Lingnan Sci., J.,* 7 : 464 (1929)[2].

[1,2]Java

117. **Kamptodiplosis** Felt

Kamptodiplosis, FELT, *Philipp. J. Sci.,* 13:290 (1918) [Genotype: *Kamptodiplosis reducta* Felt]; *Bull. N. Y. St.*

Mus., 257 : 160 (1925); *Lingnan Sci.*, *J.*, 7 : 448 (1929). MANI, *Indian J. Ent.*, 7 : 219 (1946).

reducta Felt

Kamptodiplosis reducta, FELT, *Philip. J. Sci.*, 13:290 (1918)[1]. [ex gall on leaf of *Siphonodon celastrineus* Griff.]; *Lingnan Sci. J.*, 7 : 464 (1929). [1]Philippines

118. **Spatholobomyia** Rao

Heliodiplosis, FELT, *Philipp. J. Sci.*, 13 : 291 (1918) (nec Hackel) *Preocc.* in Hackal *Protozoa*); *Bull. N. Y. St Mus.*, 257 : 161 (1925); *Lingnan sci. J.*, 7 : 448 (1929).

Spatholobomyia RAO, *Rec. Indian Mus.*, 48 (3-4): 41 (1950) [Genotype: *Spatholobomyias patholobi* (Felt).] [New name]. [1]Philippines

spatholobi Rao

Heliodiplosis spatholobi FELT *Philipp. J. Sci.*, 13 (6): 29[1]. (1918)[1]. [ex gall on leaf of *Spatholobus gyrocooipus* (Wall.) Beisth.].

Spatholobomyia spatholobi, Rao, *Rec. Indian Mus.*, 48 (3-4): 41 (1950) (New name).

119. **Bremia** Rondani

Diplosis, (partim), H. Löw, *Dipt. Beitr.*, 4 : 34 (1850).

Cecidomyia (partim), WALKER, *Ins.*, *Britann. Dipt.*, 3:116 (1856).

Bremia, RONDANI, *Atti Soc. Sci. Nat. Milano*, 2 : 287 (1860) [Genotype: *Bremia decorata* H. Löw]. KIEFFER, *Gen. Ins.*, 152 : 165 (1913). FELT, *Bull. N. Y. St. Mus.*, 257 : 158 (1925); *Lingnan Sci. J.*, 7 : 450 (1929). MANI, *Rec. Indian J. Ent.*, 7 (1&2): 217 (1946).

macrofilum Felt

Bremia macrofilum, FELT, *Philipp. J. Sci.*, 14: 287 (1919)[1]; *Lingnan Sci. J.*, 7 : 464 (1929). [1]Philippines

120. **Dactylodiplosis** Rübsaamen

Dactylodiplosis, RUBSAAMEN, *Sitzungsb, Ges. Naturf. Freunde Berlin*, 9 : 452 (1915) [Genotype: *Dactylodiplosis hesteriae* Rübsaamen]. FELT, *Bull. N. Y. St. Mus.*, 257 : 158 (1925); *Lingnan Sci. J.*, 7 : 446 (1929). MANI, *Indian J. Ent.*, 7 : 271 (1946).

memoni Mani

Dactylodiplosis ? memoni, MANI, *Indian J. Ent.*, 5 : 160 (1948) [Reared from *Pseudococcus* sp.] [1]Delhi

121. **Thomasiniana** Strand

Diplosis (partim), RÜBSAAMEN, *Ent. Nachr. Berlin*, 19: 161 (1893).

Clinodiplosis (partim), KIEFFER, *W. Ent. Z.*, 15: 98 (1896).

Thomasia, RUBSAAMEN, *Z. wiss Insektenbiol*, 7: 168 (1911) (not of Poche-Preocc.). KIEFFER, *Gen. Ins.*, 152: 236 (1913). FELT, *Bull. N. Y. St. Mus.*, 257: 159 (1925); *Lingnan Sci. J.*, 7 : 218 (1929). MANI, *Indian J. Ent.*, 7:218 (1946).

Thomasiniana, STRAND, *Arch, Naturg.*, 82 A (5): 82 (1916) [Genotype: *Thomasiniana oculiperda* (Rübsaamen]. RAO, *Indian J. Ent.*, 11 (2): 117 (1951).

salvadorae Rao

Thomasiniana salvadorae, RAO, *Indian J. Ent.*, 11 (2): 117 (1951). [ex gall No. 168 on stem of *Salvadora persica*] Roxb.]. MANI, *J. R. Asiatic. Soc. Bengal*, 14 : 145 (1948).

[1]Agra, Udaipur, Ajmer

HOST PLANT INDEX

MIDGE	HOST PLANT
acaciae, Schizomyia	Acacia leucopholea Willd.
acalyphae, Schizomyia	Acalypha stipulacea Koltz.
aequipalpis, Minertomyia	Ficus rumphi Blume,
aeschynanthus-perottetti, Prolasioptera	Aeschynanthus perottetti A. Dc.
amraemyia, Amradiplosis	Mangifera indica Linn.
andropoginis, Contarinia	Andropogon aorghum Bort.
andropoginis, Dyodiplosis	Apludia varia Hack.
	Andropogon annulatus Forsk.
	Andropogon contortus Linn.
	Andropogon pertusus Willd.
	Andropogon sehoenanthus Linn
	Panicum flavidum Retz.
antidesmae, Ctenodactylomyia	Antidesma leptocladum Tub.
apludae, Orseoliella	Apluda varia Hack.
artemisiarum, Clinodiplosis	Artemisia sp.
artocarpi, Camptomyia	Artocarpus integrifolia L.
artocarpi, Rübsaamania	Artocarpus integrifolia L.
assamensis, Schizomyia	Rubas assamensis Focke.
banksi, Hyperdiplosis	Cissus adnata Wall.
beguni, Asphondylia	Solanum melogena L.
bivalviae, Lobopteromyia	Acacia catachu Willd.
boerhaaviaefoliae, Punarnavomyia	Boerhaavia repunda Willd.
	Boerhaavia diffusa Linn.
boerhaaviae, Neolasioptera	Boerhaavia sp.
brideliae, Toxomyia	Bridelia stipularis Bl.
brunnigallicola, Amradiplosis	Mangifera indica Linn.
bryoniae, Lasioptera	Bryonia laciniosa Linn.
bursaria, Asphondylia	Symplocos fasciculata Zoll.
callicarpae, Asphondylia	Callicarpa logifolia Linn.

Midge	Host Plant
orientalis, Profeltiella	Siphonodon celastrinus Griff.
orientalis, Stephaniella	Lepidagathis javanica Bl.
oryzae, Pachydiplosis	Ophiurus corymbosus Gaert.
	Oryza sativa Linn.
	Panicum stagninum Retz.
	Ophiurus exaltatus O. Ktz.
osbeckiae, Asphondylia	Osbekia sp.
paederiae, Itonida	Paederia tomentosa Blume
pandani, Trishormomyia	Pandanus nitidus Rurz.
paniculi, Lasioptera	Panicum carinatum Persl.
	Panicum prostratum Lamark
paspalumi, Itonida,	Paspalum sirobiculatum Linn.
paspali, Parallelodiplosis	Paspalum sirobiculatum Linn.
penniseti, Cecidomyia	Pennisetum cenehroides Rich.
penniseti, Ionida	Pannisetum alopecuros Rich.
	Pennisetum cenchroides Steud.
peshawarensis, Anjeerodiplosis	Ficus carica L.
philippinensis, Cecidomyia	Spatholobus philippinensis Meer.
phyllanthi, Asphondylia	Phyllanthus emblica
	Emblica officinalis Gaertn.
pipericola, Trichoperrisa	Piper nigrum Linn.
pipaldiplosis, Pipaldiplosis	Ficus religiosa Linn.
plumosa, Dyodiplosis	Andropogon annulatus Forsk.
	Iscilema laxum Hack.
polyalthiae, Colopedila	Polyalthia subcordata Bl.
pollinia, Lopesiella	Eulalia tristachyao Ktz.
pongamiae, Asphondylia	Pongamia glabra Vent.
pongamiae, Myricomyia	Pongamia glabra Vent.
pongamiae, Microdiplosis	Pongamia glabra Vent.
prosopidis, Lobopteromyia	Prosopis spicigera Linn.
	Prosopis juliflora
pulcherima, Contarinia	Symplocos theaefolia D. Don.
quadrilobatus, Oligotrophus	Maesa perrottetiana A. D.
radicis, Oligoxenomyia	Freyeinatia valida Ridl,
reducta, Kamptodiplosis	Siphonodon celastrineus Griff.
ricini, Asphondylia	Ricinus communis Linn.
ricini, Camptomyia	Ricinus communis Linn.
riveae, Asphondylia	Rivaea hypocrateriformis Choisy
saligenus, Oligotrophus	Salix elegans Wall.
saltata, Contarinia	Andropogon sorghum Bort.
salvadora, Thimasiniana	Salvadora perisica Roxb.
schefflerae, Scheuria	Schefflera sp.
sesami, Asphondylia	Sesamum indicum Linn.
seminis, Itonida	Pennisetum typhoideum Gertu.
semilacis, Asphoxenomyia	Smilax modestat Dc.
sp. Neolasioptera	Machilus odoratissima Nees
spatholobi, Spatholobomyia	Spatholobus gryrocarpus (Wall).
spondiasi, Mycodiplosis	Spondias mombin
strobilanthi, Asphondylia	Strobilanthus cernuus Bl.
symphoremae, Luzonomyia	Symphorema luzonium. F. Vill.
tamaricum, Misispatha	Tamarix dioica Roxb.
	Tamarix gallica

MIDGE	HOST PLANT
	Polyantha simiarum
	Morus alba Bureau.
indica, Diadiplosis	Phenococcus hirsutus
	Pseudococcus corymbatus
indica, Dyodiplosis	Andropogon shoenanthus Linn.
incerta, Schizomyia	Eurya japonica Thumb.
indica, Schisomyia	Tecoma undulata D. Don.
indica, Mycodiplosis	Pennisetum typhoideum Gertn.
	Lucerne sp. ,
indicus, Oligotrophus	Capparis viminea Low
ipomaeae, Asphondylia	Ipomaea staphylina Roem & Sch.
ischaemi, Hormomyia	Ischaemum pilosum Hack.
ischaemi, Orseoliella	Inschaemum ciliare Retz.
ixora, Asphondylia	Pavetta (Ixora) timoriensis Decne
javanica, Lasioptera	Melothria sp.
javanica Orseoliella	Imperata arundinacea cyrill.
	Imperata cylindrica Beauv.
javanica, Prolasiptera	Melothria amplexicaulis
	Melothria feterophylla Cogn.
	Melothria perpusilla Cogn.
javanica, Parallellodiplosis	Saccolepis indica Chese
keshopurensis, Amradiplosis	Mangifera indica Linn.
lantanae, Asphondylia	Lantana camara L.
	Lantana indica R.
laporteae, Schizomyia	Laportea stimulans Miq.
leeae, Asphondylia	Leea sambusina Willd.
linderae, Dephnephila	Lindera pulcherrima Benth.
lini, Dasyneura	Linum usitatisslmum
longispatha, Lasioptera	Camellia drupifera Lour. L.
listeae, Asphondylia	Litsea sp.
luzonensis, Tricontarinia	Parashorea malaanonan Merrill
maeruae, Schizomyia	Maerua arenaria Hook.
malabarensis, Cecidomyia	Piper nigrum L.
mangifera, Dasyneura	Mangifera indica Linn.
mangiferae, Indodiplosis	Mangifera indica Linn.
mangiferae, Rhabdophaga	Mangifera indica Linn.
mangiferae, Oligotrophus	Mangifera indica Linn.
manilensis, Lasioptera	Leea manilensis Walp.
	Leea sambucina Wlld.
mathuri, Horidiplosis	Ficus glomerata Roxb.
matteina, Procontarinia	Mangifera indica Linn.
mimusopsicola, Pruthidiplosis	Mimusops hexandra Roxb.
milleffolii, Rhopalomyia	Achillea millefolium Linn.
monticola, Dyodiplosis	Andropogon monticola Schult.
morindae, Asphondylia	Morinda tinctoria Roxb.
morinda, Camptomyia	Morinda tinctoria Roxb.
moringae, Stictodiplosis	Moringa sp.
nodifex, Clinodiplosis	Cyclostemon assamensis Hook.
nodosa, schizomyia	Moschosma polystachua Benth.
odinae, Odinadiplosis	Odina wodier Roxb.
orientalis, Diceromyia	Phoebe declinata Nees
orientalis, Oryseoliella	Oplismenus compositus Beauv.

MIDGE	HOST PLANT
	Callicarpa eriollona Schaner
campanulata, Acroectasis	Sabia campanulata
capsici, Asphondylia	Capsicum sp.
caudata, Contarinia	Apluda varia Hack.
	Andropogon schoenanthus Linn.
	Andropogon contortus Linn.
cardamoni, Hallomyia	Eletteria cardamoni Maton
cephalandrae, Neolasioptera	Coccinia indica W & A.
champoni, Banidiplosis	Quercus dilatata
charterjii, Sissudiplosis	Dalbergia sissoo Roxb.
cheriani, Schizomyia	Ipomoea cairica Sweet
cocculi, Schizomyia	Cocculus hirsutus Diels.
cornea, Dyodiplosis	Ischaemum ciliare Retz.
crataevae, Aschistonyx	Crataeva religiosa Forst
crataevae, Neolasioptera	Crataeva religiosa Forst
cynodontis, Orseolia	Cynodon dactylon Pers
	Panicum fluitans Retz
dalbergiae, Contarinia	Dalbergia sissoo Roxb.
dattai, Cecidomyia	Aegle marmelos Corr.
dhakae, Colpodia	Butea frondosa Roxb.
digerae, Asphondylia	Digera arvensis Forst.
diplodisci, Schizomyia	Diplodiscus paniculatus Turcz.
dosua, Oxasphondylia	Indigofera dosua
echinata, Oxasphondylia	Indigofera gerardiana
echinogalliperda, Amradiplosis	Mangifera indica Linn.
elatostemma, Dasyneura	Elatostemma sp.
eragrostidis, Contarinia	Eragrostis unioliodes Nees
eragrostisae, Cecidomyia	Eragrostis amabius W & A.
eriochloa, Lasioptera	Eriochloa polystachya H. B. K.
falcata, Lasioptera	Momordica charantia Linn.
	Momordica dioica Roxb.
falcaria, Stefaniella	Avicenia officinalis L.
fici, Asphondylia	Ficus nota
fici, Dyodiplosis	Ficus glomerata Roxb.
fici, Horidiplosis	Ficus infectoria Roxb.
floricola, Oxasphondylia	Indigofera gerardiana
fluitans, Lasioptea	Panicum fluitans Retz.
fluvialis, Dyodiplosis	Cynodon dactylon Pers.
	Panicum fluitans Retz.
garcinia, Gnesiodiplosis	Garcinia dioica Bl.
glandifex, Daphnephila	Machilus gamblei King
gossypii, Dasyneura	Gossypium sp.
graminis, Orseoliella	Andropogon squrrosus Hack
graminicola, Pachydiplosis	Cynodon dactylon Perz.
grewiae, Asphondylia	Grewia stylocarpa Warb.
haasi, Daphnephila	Machilus gamblei King.
hassi, Panteliola	Artemisia sp.
hibisi, Camptomyia	Hibuscus sp.
humata, Gynodiplosis	Humata alpina Moore
impatientis, Thorodiplosis	Impatiens platypetala
inaequipalpis, Meinertomyia	Odina wodier Roxb.
	Buchnamia latifolia Roxb.

MIDGE	HOST PLANT
tenuispatha Alassomyia	Mangifera indica Linn.
tephrosiae, Asphondylia	Tephrosia candida Dc.
tetrastigma, Dasyneura	Tetrastigma pergamaceum Planch.
textor, Lasioptera	Polygonum molle D. Don.
tricocecidarum, Asphondylia	Acacia leucophloea Willd.
trilobata, Lasioptera	Schima walchii Chosky Echinocarpus dasycarpus
uichancoi, Kronodiplosis	Barringtonia luzonensis Rolfe.
utriculi, Asphondylia	Dichrostachys cinera W & A.
vernoniae, Diceromyia	Vernonia lancifolia Meer.
villabrunneae, Schizomyia	Villebrunnea rubescens Bl.
viridigallicola, Amradiplosis	Mangifera indica Linn.
viteae, Asphondylia	Cissus trifolia K. Sch.

HOST PREFERENCES IN *RETITHRIPS SYRIACUS* (MAYET)

By, T. N. ANANTHAKRISHNAN, B. Sc. (Hons.), F. Z. S., F. R. E. S., *Lecturer in Zoology, Loyola College, Madras-6.*

Retithrips syriacus,[1] a polyphagous, cosmopolitan species, was first recorded in India by Seshadri and Ananthakrishnan (8). Recently I found the Nymphs and adults feeding in groups exclusively on the leaves of a variety of host plants in completely isolated localities. A notable feature, however, was that in spite of its polyghagous nature, it exhibits special preference to *Ricinus communis* and cotton (*Gossypium herbaceum*). The accompanying table gives an idea of the host range and distribution of *Retithrips* in South India.

Host Plant	Nat. Order	Locality	Collector	Date
Cotton	Malvaceae	Cuddalore Bapatla Madras	E. R. G. Menon Mohan Rao Ananthakrishnan	31-5-1952 June 1952 Dec. 1953
Grapevine	Ampelidae	Chengalpet	E. R. G. Menon	14-6-1952
Cassia auriculta	Caesalpineae	Madras	Ananthakrishnan	4-7-1951
Acalypha	Euphorbiaceae	,,	-do-	4-7-1951
Ricinus communis	-do-	,,	-do-	Dec. 1952
Punica granatum	Funicace	,,	-do-	Jan. 1954

Mode Of Infestation.—Their presence in considerable numbers has been noted by the author specially in castor, in widely separated areas in Madras like Adyar, Chetpet, Teynampet and Nungumbakkam. Examination of the infested plants revealed the presence of adults and nymphs *almost in equal numbers on both the sides of the leaves* instead of the usual lower surface. Most of the plants in a given area were already attacked or were being invaded. A conspicuous feature, however, was that no visible changes were brought about as a result of the presence of these individuals, so that the plants could be said to be completely resistant to the attack. The growth rate, the yield, the nature of the plant parts and the height of the normal and infested plants remained the same. Cotton plants were also similarly infested and as in castor. The infestation was profuse on both the sides. As against these preferred hosts, the number on pomegranate, *Cassia* and *Acalypha,* was limited, just a few individuals being present. Their distribution on the upper surface of the leaves was very meagre and in the case of pomegranate not a single individual was found on the upper surface.

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[1] Mayet (1890. Insects de la vigne, 9451) originally described this specics as *Heliothrips syriacus.*

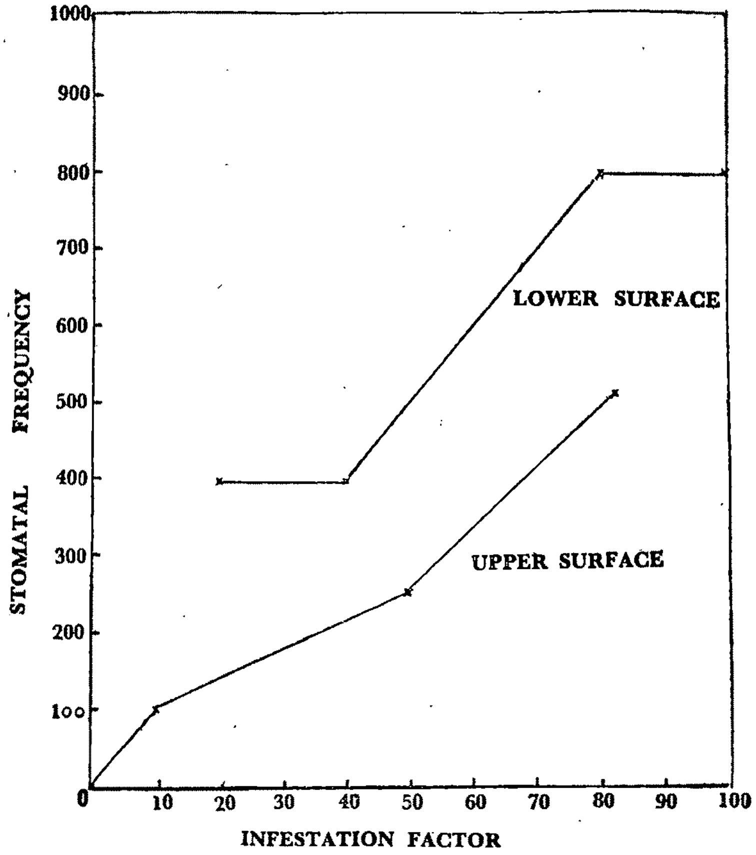

Fig. 1. Relation between stomatal frequency on leaves and infestation factor by *Retithrips* in Madras.

Relation between Stomatal frequency and Infestation factor.—In the investigation of the probable causes for host preference and preference for attack on one or both sides of the leaf, the stomatal frequency of the hosts concerned was calculated, in terms of the number of stomata present per square millimetre of leaf surface, both upper and lower. Similarly the *infestation factor* i. e., the number of individuals (adults and nymphs) per hundred square centimetre area of the leaf, was also calculated (vide table & graph). The stomatal frequency and the infestation factor appear to be closely related. In plants like pomegranate, where the stomatal frequency on the upper side of the leaf, is nil, no individuals were found. Similarly in the case of *Acalypha*, where the stomatal frequency on the upper side was lower than castor, the number of individuals was also restricted. The number of individuals on the upper surface of the leaf appears to be low due to the lesser stomatal frequency and may not be due to the difference in epidermal thickness as has been suggested for *Thrips tabaci* on cotton by Wardle and Simpson (9). The purity of infection in castor and cotton was a hundred per cent.

Retithrips POPULATION COUNT FOR CASTOR AND COTTON

	CASTOR							COTTON					
	Locality 1		Locality 2		Locality 3			Plant 1		Plant 2		Plant 3	
	upper side	lower side	upper	lower	upper	lower		upper	lower	upper	lower	upper	lower
No. of adults	5	13	5	15	4	13	adults	9	7	3	6	1	5
Males	nil	2	nil	3	nil	3	Males	1	1	nil	1	nil	1
Females	5	11	5	12	4	10	Females	8	6	3	5	1	4
Nymphs	74	160	75	183	78	128	Nymphs	79	109	43	78	16	44
Sex-ratio	0:5	1:5	0:5	1:4	0:4	1:3	Sex-ratio	1:8	1:6	0:3	1:5	0:1	1:4
Percentage of adults to nymphs	7	8	7	8	5	11	Percentage of adults to nymphs	12.5	7	7	8	6.25	11

<table>
<tr><th rowspan="3">Host</th><th colspan="6">Infestation factor and stomatal frequency (Average per 6 leaves)</th></tr>
<tr><th colspan="4">No. per 100 sq. cm.</th><th colspan="2">No. of stomata per sq. mm.</th></tr>
<tr><th colspan="2">lower</th><th colspan="2">upper</th><th rowspan="2">lower</th><th rowspan="2">upper</th></tr>
<tr><th></th><th>Adult</th><th>Nymph</th><th>Adult</th><th>Nymph</th></tr>
<tr><td>Castor</td><td colspan="2">$\underbrace{21 \quad 80}_{101}$</td><td colspan="2">$\underbrace{11 \quad 68}_{79}$</td><td>800</td><td>500</td></tr>
<tr><td>Cotton</td><td colspan="2">$\underbrace{12 \quad 60}_{72}$</td><td colspan="2">$\underbrace{4 \quad 40}_{44}$</td><td>800</td><td>250</td></tr>
<tr><td>Pomegranate</td><td colspan="4">2 individual per 5 sq. cm
(=40 per 100 sq. cms</td><td>400</td><td>nil</td></tr>
<tr><td>Acalypha</td><td colspan="2">$\underbrace{4 \quad 16}_{20}$</td><td colspan="2">$\underbrace{2 \quad 7}_{9}$</td><td>400</td><td>100</td></tr>
</table>

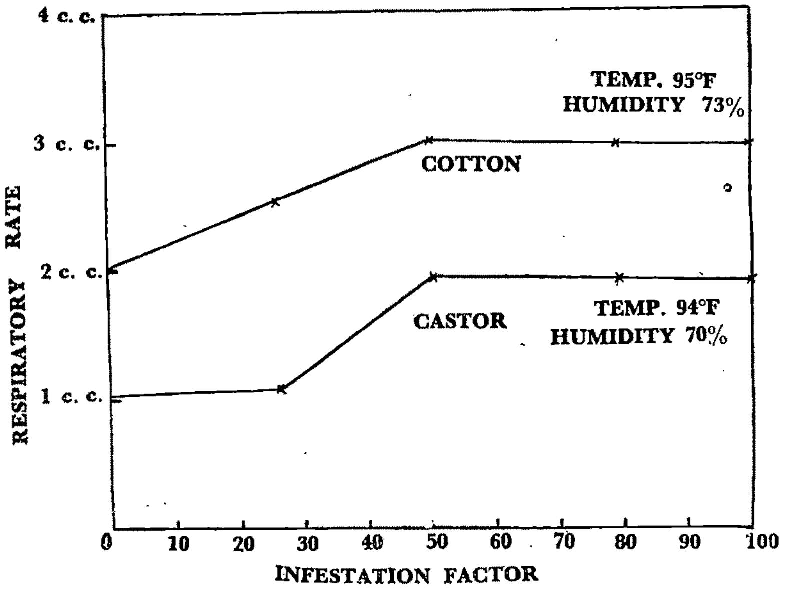

FIG. 2. Relation between respiratory rate of leaf and infestation factor by *Retithrips* in Madras.

Relation between respiratory rate and infestation factor.—The respiratory rate was calculated for leaves with different degrees of infestation, normal leaf, and leaf with the maximum infestation. The results are plotted in fig. 2. In both castor and cotton the rates of respiration of the leaf; increased gradually up to infestation factor about 50, and thereafter respiratory rate was uniform. This uniformity in the respiratory rate after an increase to a certain degree can be termed as the *immunity line*, the probable cause for which lies in the resistance of the leaves concerned to attack.

Probable Causes for host resistance.—Histological sections of the leaves of castor and cotton, at various stages revealed absolutely no cellular deformation or histological lesions. The leaf structure was same, irrespective, of the infestation factor. The mouthcone of *Retithrips* is short and blunt and the method of insertion the stylets, since no cell gashes appear to be made, is through the closely spaced stomata. As a result of the absence of cell gashes no necrosis is also seen. At the same time, the infected leaf does not wither but maintains the green colour. This green colour is perfect on the lower sides of leaves and the upper surface is silvery, due to the accumulation of epidermal secretions as a result of stimulus due to the insects, larval exuviae, etc. The green colour however appears when the leaves are washed well. The maintenance of the normal leaf structure may probably be due to the fact that very little sap is sucked at a time and this loss of sap is made good soon, or cell turgidity is maintained by the osmotic flow of water from adjacent cells.

In older leaves the proportion of adults to larvae is very small *viz.* about 8%, whereas in the younger leaves, the adults are found in greater numbers than the nymphs. The fact that the adults are numerous in the upper, younger leaves of the plant, seems to show that it is a preparation for fertilisation and oviposition in the younger leaf. The general sex-ratio is usually between 1 : 4 and 1 : 5, the females always predominating.

SUMMARY.

1. *Rethrips syriacus* (*Mayet*) a cosmopolitan species, has a special host preference to castor and cotton in South India.

2. Even acutely infested cotton and castor plants, do not show any visible effect of attack. The thrips occur on both sides of the leaf, the number being lower on the upper side.

3. This reduction on the upper side or confinement to lowerside alone, is neither due to negative phototropism, nor due to epidermal thickness. The chief cause is due to the differences in the higher stomatal frequency on the upper side.

4. The number of individuals *i. e.*, infestation factor is proportional to stomatal frequency, which is maximum in castor and the minimum on the upper surface, since no stomata are found.

5. An immunity line is seen when the respiratory rate and the infestation factor are correlated, showing that after a certain degree of infestation, the respiratory rate remains the same irrespective of the rate of infection.

6. No cell gashes or lesions are produced by the feeding, showing that the method of insertion of sytlets is through the stomata. The leaf, inspite of feeding, retains its normal green colour.

ACKNOWLEDGMENTS

I wish to express my sincere thanks to Prof. M. S. Mani for his kind criticism and advice. My thanks are also due to Sri. D. Padmanabhan who has helped me in various ways.

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APPLICATION OF PHYSICO-CHEMICAL METHODS FOR STUDYING THE COMPOSITION OF INSOLUBLE METALLIC FERRO AND FERRICYANIDES : A REVIEW OF THE RECENT WORK

PART I.—AMPEROMETRIC (POLAROGRAPHIC) METHOD

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INTRODUCTION

The method of amperometric (polarographic) titrations (1) for the study of the precipitation of insoluble metallic ferrocyanides and ferricyanides has only recently been adopted. A dropping mercury electrode (D. M. E.) or sometimes a rotating platinum micro-electrode is used as a cathode in an electrolytic cell in which an external (or an internal) depolarised electrode such as saturated calomel electrode (S. C. E.) serves as an anode. To carry out an amperometric titration it is essential to know the behaviour of the reactants at the D. M. E. and therefore as a preliminary step, the polarograms of the reactants in a suitable supporting electrolyte medium are obtained. Since oxygen is readily reduced at a fairly low cathodic potential, its removal from the reactant solutions is essential and this is usually done by bubbling into the solution an inert gas such as nitrogen or hydrogen for about 30 minutes. The polarograms of most substances have an interfering maximum which may be eliminated by adding to the solutions a current maximum suppressor such as gelatine, methyl-red, etc. in small optimum concentrations. A schematic polarogram for the reduction of a metal ion at the D. M. E. appears in fig. 1. Up to the decomposition potential V_1 the reduction of the metal ion is not appreciable and the diffusion current passing through the cell is the residual current of the supporting electrolyte. On increasing the cathodic potential further, the diffusion current through the cell increases rapidly and reaches a limiting value for a potential equal to V_2 or greater. The diffusion current at this stage is proportional to the concentration of the metal ion in the solution. (4)

For precipitating the metallic *ferrocyanides*, sodium or potassium ferrocyanide is generally used. The ferrocyanide is not reduced at the D. M. E. (14) and the alkali ions have a decomposition potential much higher than that at which the diffusion current due to the discharge of the ions to be precipitated has a limiting value. If, therefore, a titration of a metal ion solution is carried out at a D. M. E. potential corresponding to V_2 (Fig. 1), the current through the cell, being proportional to the concentration of the metal ion, will decrease linearly (curve 1, fig. 2) on the addition of the ferrocyanide solution, and will finally reach a steady minimum value equal to the residual current of the supporting electrolyte. If the titrations are carried out in the reverse manner, taking the ferrocyanide solution in the cell, the current through it remains at the level of the residual current of the supporting electrolyte till the whole of the ferrocyanide is precipitated and increases thereafter linearly with the further addition of the metal ion solution (curve 2, fig. 2). Thus for any quantity of the solution of either reactant taken in the cell, the equivalent quantity of the titrant can be obtained quite accurately from the point of intersection of the two straight line portions of the graphs and the composition of the precipitate can be computed from the strengths and the equivalent volumes of the reactant solutions.

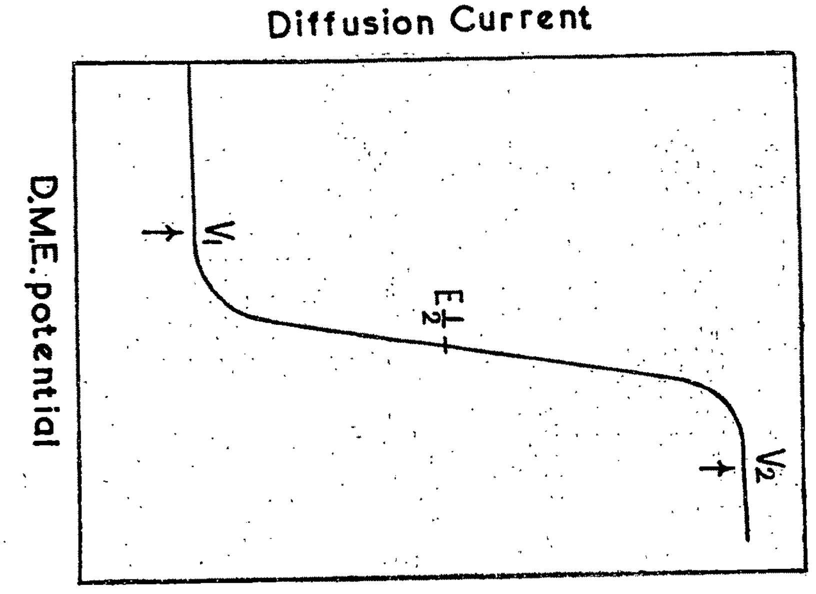

Fig. 1 Schematic polarogram for reduction of metal ion at D. M. E.

For precipitating *ferricyanides* a solution of sodium or potassium ferricyanide is employed. Unlike the ferrocyanide, the ferricyanide ion is easily reduced at the D. M. E., its half wave potential being+0.2 volt *vs* S. C. E. (12) and the diffusion current due to its reduction reaches a limiting value at a rather low cathodic potential (—O.3 volt *vs* S. C. E.). Therefore, the precipitation of the ferricyanides would give rise to two cases of titration curves:

Case i. The reduction of the metal ion commences at a negative potential higher than that at which the diffusion current due to the ferricyanide ion reaches a limiting value. If the D. M. E. is given a cathodic potential corresponding to V_1 (Fig. 1) and the titration is carried out by adding the ferricyanide solution from the burette, the titration curve would be similar to curve 2 fig. 2. In the reverse titration, at the same D. M. E. potential, the titration curve will be similar to curve 1, fig. 2. However, if the D. M. E. potential is set corresponding to V_2 (Fig. 1) i. e., where the diffusion current due to the electro-reduction of the metal ion has a limiting value, and where the ferricyanide ion is also reduced, in direct as well as reverse titrations, the shape of the titration curve will be as shown in curve, 3, fig. 2, the first part is a steep fall due to the decreasing concentration of the reactant taken in the cell, and the latter part corresponds to the increasing concentration of the titrant. The minimum in the curve represents the point of equivalence.

Case ii. When the diffusion current due to the reduction of the metal ion has a limiting value at a very low cathodic potential (e. g., copper, and silver) in the direct as well as reverse titration with the ferricyanide solution the titration curve will have the same shape as shown in curve 3 fig. 2.

EXPERIMENTAL PROCEDURE

The titrations are carried out with the help of a manual polarographic arrangement (11). The use of amperometric method has not been as widely adopted in this country as its suitability deserves. We have, elsewhere (5) described the details of setting up a manual polarographic arrangement along with a titration assembly using the common laboratory apparatus. The solution

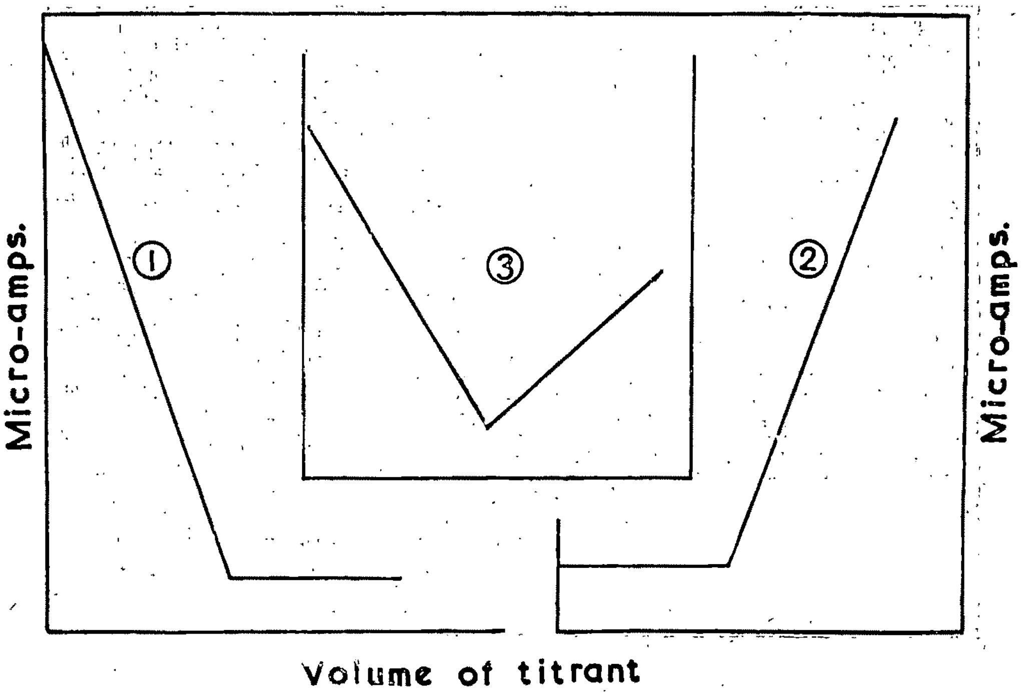

Fig. 2.

to be titrated (.001 to .005 M.) is prepared in a suitable carrying electrolyte and gelatine is added to it in the proportion of 1 ml of 0.05% gelatine solution to 100 ml of the reactant solution. The solution is then freed from oxygen. The suitable cathodic potential for the titration is applied to the D. M. E. by a potentiometric arrangement. The drop time of dropping mercury electrode is adjusted to about 3.5 secs. The titrant which is about 20 times stronger than the solution to be titrated is added from a micro-burette, and the current passing through the cell after each addition of the titrant is measured. The small error in the observed current, due to the dilution effect, is corrected by multiplying the observed value of the current by the factor $\frac{V+v,^{12}}{V}$ (12) where 'V' is the initial volume of the solution in the cell, and 'v' is the volume of the titrant added up to any stage. Sometimes the titrations have to be carried out at higher temperatures to minimise such effects as adsorption of the reacting ions on the precipitate, and the slow formation and the slow settling of the precipitate. Control of *p*H helps in reducing the hydrolysability of the precipitate.

RESULTS

The precipitation of metallic ferrocyanides and ferricyanides has not been studied in as great a detail by the amperometric method as by the application of other physico-chemical methods. A review of the up-to-date work is given below, and the scope for further work has been indicated.

Zinc ferrocyanide.—Spalanka (15) carried out the titration of $[Fe(CN)_6]^{-4}$ with zinc in O.2N HCl at D.M.E. potential of—1.2 volts. He recommended that the zinc solution must be added to potassium ferrocyanide. The product of the reaction corresponded to $K_2Zn_3[(Fe(CN)_6]_2$. Nimmer, Hamm and Lee (13) carried out the direct amperometric titration of zinc with potassium ferrocyanide in a supporting electrolyte of 1.7M ammonium acetate at D. M. E. potential of—1.4 volts *vs.* S. C. E., the precipitate at the equivalence point corresponding to $Zn_2Fe(CN)_6$. Woodson, Johnson and Cooper (17) carried out the titration in N/10 KCl and at D. M. E. potential of—1.30 volts in highly acidic medium and their results supported the findings of Spalanka (15) regarding the composition of the precipitate at the equivalence point. We (6) have also arrived at the same result in respect of composition of the precipitate, but in our opinion zinc solutions with *p*H lower than 2.0 should not be used, for then the hydrogen wave gets superimposed upon the cathodic reduction wave of zinc so that the measured limiting diffusion current cannot be regarded as proportional to the concentration of Zn^{++} ion alone. At 60°C the titration can be also used for the estimation of zinc.

Copper ferrocyanide.—The amperometric titration of Cu^{++} by potassium ferrocyanide has been done by Chovnyk and Kleibs (2) in presence of Na^+, K^+, Li^+, H^+, and K^{++} H^+ ions. In the absence of K salts the end point corresponded to $Cu_2Fe(CN)_6$. Addition of a K salt resulted in the increased consumption of

$K_4Fe(CN)_6$ until in normal solutions the end point corresponded to $5Cu_2Fe(CN)_6$. $K_4Fe(CN)_6$. The same was true of Na and Li salts but to a lesser degree. For best results the titration should be done in HCl in presence of 1 to 1.5 M KCl solution.

Lead ferrocyanide.—We (7) have carried out the titration of Pb^{++} with potassium ferrocyanide at the D. M. E. potential of—0.55 volt *vs.* S. C. E. where the diffusion current due to cathodic reduction of Pb^{++} has a limiting value, the composition of the precipitate at the equivalence point corresponds to the formation of the normal compound $Pb_2Fe(CN)_6$. The titration has been found to be suitable for estimation of small amounts of lead. The reverse titration of ferrocyanide with lead nitrate has also been carried by Kolthoff and Pan.(9)

Nickel, Copper and Zinc ferricyanides.—The study of the reaction for the precipitation of these ferricyanides has been carried out by Chovnyk and Kuzmina(8). Nickel sulphate solution (.00944 M) was titrated with 0.1 M potassium ferricyanide in a supporting electrolyte medium of KCl, KNO_3 $NaNO_3$ or H_2SO_4 at various concentrations. In all titrations the end point corresponded to $Ni_2[(Fe(CN)_6]_2$. By using a rotating platinum electrode the sensitivity of the method could be increased to permit determination of still smaller quantities of nickel. In the titration of zinc in KCl and HCl the end point corresponded to $Zn_3[Fe(CN)_6]_2$, and similarly for copper there was a sharp end point corresponding to the precipitation of $Cu_3[Fe(CN)_6]_2$. Copper can be titrated even in the presence of iron if the latter ions be complexed with sodium fluoride.

Cobalt ferricyanide.—Direct and reverse amperometric titrations of cobalt chloride have been carried out by us(5) with potassium ferricyanide at—0.8 volt *vs.* S. C. E. where the electro reduction of Co^{++}does not commence. The precipitate at the equivalence point corresponded to the composition $Co_3\,[Fe(CN)_6]_2$.

Silver ferricyanide.—We(8) have carried out the titration of ferricyanide with silver nitrate in 0.1 M KNO_3 medium at D. M. E. potential of -0.35 volt *vs.* S. C. E. where the diffusion current due to the cathodic reduction of both $Fe(CN)_6^{---}$ and Ag^+ ions has a limiting value. The precipitate at the equivalence point corresponded to the formation of $Ag_3Fe(CN)_6$. This titration may be used for estimating small amounts of ferricyanide.

The method can be extended to the amperometric study of the precipitation of several other ferricyanides as those of manganese and cadmium in which the formation of normal ferricyanides has already been shown by electrometric titrometry and also by the X-ray diffraction by their gels (16). The amperometric method has the promising prospects of being adopted for estimation of actions as Pb^{++} and Zn^{++} by ferrocyanide and Cu^{++}, Co^{++}, and Zn^{++} etc. as ferricyanides and also of ferricyanide by silver nitrate in the concentration range 1 - 5 x 10^{-3} M, the range which is too concentrated for use of colorimetric methods and is very dilute for the application of the classical volumetric methods.

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Our thanks are due to Professor R. P. Mitra, D. Sc., F. N. I., for helpful discussions.

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THERMAL EXPANSION OF CRYSTALS

IX.—CANE-SUGAR

By S. S. SHARMA, *Professor of Physics, Government Hamidia College, Bhopal.*

ABSTRACT

By employing a modified form of Fizeau's original interferometric method, thermal expansion of a monoclinic crystal of cane-sugar has been determined for the first time. The crystal is shown to exhibit great anisotropy in thermal expansion, the principal coefficients of expansion being $\alpha_{11}=68.00\text{X}10^{-6}$; $\alpha_{22}=52.35.\text{X}10^{-6}$; $\alpha_{33}=29.70\text{X}10^{-6}$.

INTRODUCTION

Most crystals belong to the monoclinic system, hence a study of their thermal expansion is of special importance. However, a survey of the literature reveals that after the pioneer work of Fizeau (1868) on one or two naturally occurring minerals, the thermal expansion of monoclinic crystals has been studied only in two cases, viz., hydragillite Al $(OH)_3$ (Megaw, 1933) and lithium sulphate monohydrate $Li_2SO_4. H_2O$ (Smith and Landon, 1949). These investigators have employed X-ray technique for their study. Recently Raman effect studies of cane-sugar have been made by Roop Kishore and Padmanabhan (1951). As big sized crystals of this substance were available, it was thought worthwhile to study its thermal expansion and to specify its thermal anisotropy in various orientations of the crystal.

THERMAL EXPANSION OF MONOCLINIC CRYSTALS

The thermal expansion coefficient in any arbitrary direction in a crystal can easily be obtained by a transformation of the axes of reference to the concerned direction. The new set of axes is defined with respect to the old ones by the usual direction-cosine scheme—

	X'_1	X'_2	X'_3
X_1	C_{11}	C_{12}	C_{13}
X_2	C_{21}	C_{22}	C_{23}
X_3	C_{31}	C_{32}	C_{33}

Since this system possesses a diad axis of symmetry, the new axes after transformation are—X_1, X_2,—X_3 (diad axis parallel to X_2 and coincident with the crystallographic b-axis). From this we can easily determine which α_{ij}'s (coefficients of thermal expansion) are equal to zero. Thus, applying a particular example of α'_{12} we have—

$$
\begin{aligned}
\alpha'_{12}= & C_{11}\ C_{12}\ \alpha_{11}+C_{11}\ C_{22}\ \alpha_{12}+C_{11}\ C_{32}\ \alpha_{13} \\
& +C_{21}\ C_{12}\ \alpha_{21}+C_{21}\ C_{22}\ \alpha_{22}+C_{21}\ C_{32}\ \alpha_{23} \\
& +C_{31}\ C_{12}\ \alpha_{31}+C_{31}\ C_{22}\ \alpha_{32}+C_{31}\ C_{32}\ \alpha_{33}
\end{aligned}
$$

It is easy to see that the direction cosines of C_{11}, C_{22}, C_{33} are different, from zero, and hence—

$\alpha'_{12}=C_{11}\ C_{22}\ \alpha_{12}=-\alpha_{12}$. Hence $\alpha'_{12}=0$

Similarly $\alpha'_{23}=0$

Again $\alpha'_{13}=C_{11}\ C_{33}\ \alpha_{13}=\alpha_{13}$

Hence $\alpha'_{13}\neq 0$ since it is unaltered by the transformation.

Thus, the scheme of the non-vanishing co-efficients α_{ij} is as follows:—

$$
\begin{matrix}
\alpha_{11} & 0 & \alpha_{13} \\
0 & \alpha_{22} & 0 \\
\alpha_{13} & 0 & \alpha_{33}
\end{matrix}
$$

Since one principal axis of the thermal ellipsoid is coincident with the diad-axis of the crystal, only two axes lying in the (010) plane remain to be determined.

PROCEDURE OF THE EXPERIMENT

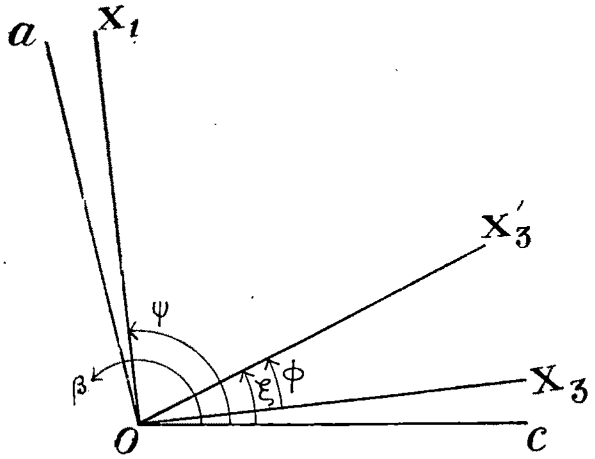
The procedure adopted in the present investigation was the same as was employed by the author (Sharma, 1950, 1951) for the study of thermal expansion of cubic as well as anisotropic crystals. All the relevant data for the identification of faces of a cane sugar crystal and for cutting of spacers in different directions are provided by Groth (1910). According to him the axial ratios are a : b : c : : 1. 259: 1 : 0. 8782 and the monoclinic angle $\beta=103°30'$. The important faces developed are a (100), c (001), r $(10\bar{1})$, p (110), p' $(1\bar{1}0)$ and q $(0\bar{1}1)$.

For the present purpose, measurements of thermal expansion in three known directions lying in the (010) plane are needed. In these investigations three sets of spacers were prepared with their altitudes respectively (i) perpendicular to the a-face (100); (ii) perpendicular to the c-face (001); and (iii) in a direction equally inclined to the two crystallographic axes and contained in the obtuse angle β.

The relative positions of the crystallographic axes a, c; the principal expansion axes of reference OX_1, OX_3 and the arbitrary direction OX'_3 lying in the b-plane (010) are shown in the accompanying figure. Then, if α_{11}, α_{33} and α'_{33} are the expansion coefficients along X_1, X_3 and X'_3 respectively—

$$\alpha'_{33}=C^2_{13}\alpha_{11}+C^2_{33}\alpha_{33}$$

Inserting the functions of angles as shown in the figure—



$$\alpha'_{33}=\sin^2\phi.\alpha_{11}+\cos^2\phi.\alpha_{33}$$

$$=\frac{\alpha_{11}+\alpha_{33}}{2}-\frac{\alpha_{11}-\alpha_{33}}{2}\cos 2\phi$$

$$=A+B\cos 2\xi+c\ \text{Sin}\ 2\xi$$

where $A=\frac{\alpha_{11}-\alpha_{33}}{2}$

$$B=\frac{\alpha_{11}-\alpha_{33}}{2}\cos 2\psi$$

$$C=\frac{\alpha_{11}-\alpha_{33}}{2}\sin 2\psi$$

Since α'_{33} and ξ can be measured, three sets of measurement give three simultaneous equations from which A, B and C can be evaluated.

From the above relations we have—

$$\tan 2\psi=C/B$$

$$\alpha_{11}=A+B/\cos 2\psi$$

$$\alpha_{33}=A-B/\cos 2\psi$$

EXPERIMENTAL RESULTS

All the necessary data are contained in the following table. The mean coefficient of linear expansion, $\bar{\alpha}$, in the temperature range (entered in the second column), is evaluated and inserted in the last column of the table.

TABLE I.

Thermal Expansion of Cane-sugar in different directions

Direction of expansion	Temp. range (°C)	$\frac{\Delta L}{L_o}.10^3$	$\bar{\alpha}\ 10^6$
⊥ — (010) plane	40-80	2.0940	52.35
⊥ — (100) plane	”	1.2648	31.62
⊥ — (001) plane	”	2.4176	60.44
Third direction in (010) plane	”	1.4728	36.82

In the present investigation, the value of 2ξ for measurement perpendicular to a-face is equal to 27°; for the direction perpendicular to c-face $2\xi=\pi$ and for the third direction equally inclined to the a and c axes it is equal to β or 103° 30′. Substituting these values of 2ξ and α'_{33} in the above equations—

$$A=48.85 \times 10^{-6}\ ;\ B=-11.59 \times 10^{-6}\ ;\ C=-15.20 \times 10^{-6}.$$

Hence $\tan 2\psi = C/B = 1.3115$

or $2\psi = 52°\ 44'$ or $232°\ 44'$

giving $\psi = 26°\ 22'$ or $116°\ 22'$ $(= -63°\ 38')$

With the latter value of ψ—

$$\alpha_{11}=68.00 \times 10^{-6}$$
$$\alpha_{22}=52.35 \times 10^{-6}$$
$$\alpha_{33}=29.70 \times 10^{-6}$$

Tis conforms with the convention that the direction of maximum expansion is along OX_1 and that of minimum expansion is along OX_3. The negative sign of ψ in this case means that OX_1 lies between Oc and $-O_a$.

The crystal of cane-sugar thus exhibits great anisotopy in thermal expansion but its crystal structure has not been studied so far hence it is not possible to correlate the thermal expansion behaviour with any other physical property.

ACKNOWLEDGMENTS

This paper forms part of a comprehensive work conducted by the author in the Physics Department of the Indian Institute of Science, Bangalore. The author takes this opportunity to express his heart-felt gratitude to Professor R. S. Krishnan for giving him all facilities to conduct this investigation. He is also thankful to Dr. G. N. Ramachandran for the discussion he had with him during the course of this work.

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PREPARATION OF MALON-o-, m- and p- CHLORANILIC ACIDS

By M. V. GEORGE and P. I. ITTYERAH, *Chemistry Department, St. John's College, Agra.*

The reaction between primary aromatic amines and ethyl malonate has been studied by various workers. Freund (5) prepared malonanilide by heating a mixture of aniline and ethyl malonate. Later Rugheimer and Hoffmann (6) studied the reaction between ethyl malonate and the three toluidines (o-, m- and p-). Whiteley (7) took up the study of the condensation of ethyl malonate with monoamines and has prepared various derivatives from the products obtained.

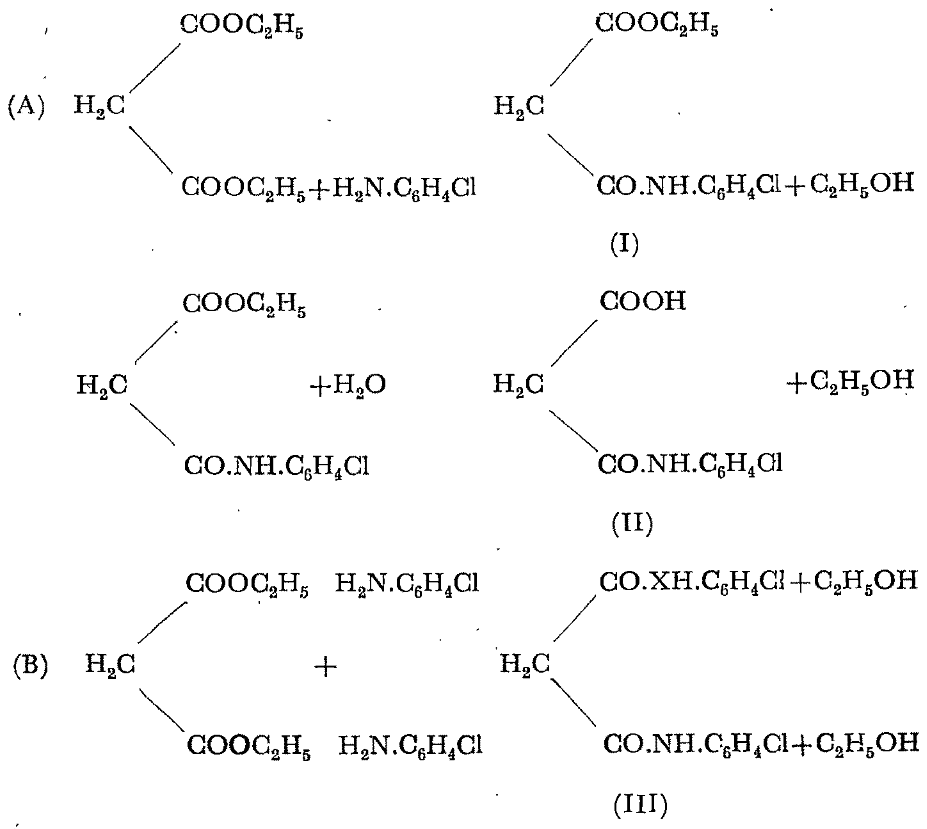
Few years later Chattaway and Mason (2) studied the reaction between many halogen substituted derivatives of aniline and ethyl malonate. They prepared p, p-dichloro malon dianilide, ethyl-p-chloro malonanilate and malon p-chloranilic acid from p-chloraniline and ethyl malonate; 2, 4, 2', 4'- tetrachloro malon dianilide, ethyl-2, 4-dichloro malonanilate and malon-2,4- dichloroanilic acid from 2,4-dichloraniline and ethyl malonate; and 2, 4, 6, 2', 4', 6',-hexa chloro malondianilide, ethyl 2,4, 6-trichloro malonanilate and malon-2, 4, 6-trichloranilic acid from 2,4,6-trichloraniline and ethyl malonate. They also tried the reaction between the analogous bromo substituted anilines and isolated the corresponding products.

Chattaway and Ohmsted (3) were able to give a convenient method for preparing malon anilic acid and the three malon-toluidic acids (o-, m- and p-) by condensing malonic ester with the corresponding primary amine and then hydrolysing the monoester formed. This work has been further extended by Ahluwalia, Haq and Ray (1).

Quite recently Chellappa and Ittyerah (4) prepared malon-1,3,4-xylidic acid by condensing freshly distilled 1,3,4-xylidine with pure ethyl malonate.

In the course of the present work an attempt has been made to prepare malon-o-, m- and p- chloranilic acids by condensing the respective chloraniline with ethyl malonate. Of these acids malon-p-chloranilic acid has already been prepared as mentioned earlier, by Chattaway and Mason (2).

The course of the reaction between ethyl malonate and a chloraniline may be represented by the following general scheme.



As is evident from the scheme three products (I, II and III) are possible.

It was possible to isolate all the products from p-chloraniline and ethyl malonate condensation, facts in agreement with the results of previous workers. But it was found that the melting points of both p, p-dichloro malon dianilide corresponding to product (III) and malon-p-chloranilic acid corresponding to (II) were slightly lower than those reported by Chattaway and Mason. p,p-dichloro malon dianilide melted at 251° C and the reported melting point was 261° C, while malon-p-chloranilic acid melted at 158° C (decomposition) as against 168° C (decomposition). The previous workers themselves have recorded that a variation in the rate of heating during melting point determination brings about appreciable changes in the melting point of these compounds. The identity of these compounds were established by suitable estimations.

In the case of m-chloraniline, both m, m-dichloro malon dianilide and malon-m-chloranilic acid could be obtained without any difficulty. The acid melted at 126° C (d) and the dianilide melted at 173° C.

The reaction between o-chloraniline and ethyl malonate was also more or less similar to the previous cases. Both o, o-dichloro malon dianilide, melting point 170° C, and malon-o-chloranilic acid, melting point 146° C (d) could be isolated.

The position of the chlorine atom in the aniline molecule seems to influence the yields of both acid and dichloro malon-dianilide. The p-isomer gave the maximum (Acid) 57.01 %, and dichloro malon dianilide 14.7%); the ortho was next in order of reactivity (Acid 54.53%, dichloro malon dianilide 14.% while the m-isomer gave the lowest yield (Acid 47.09%, dichloro malon-dianilide 13.9%).

It is interesting to note that the melting points of these compounds also follow more or less the same order as para, ortho and meta (Refer Table 1).

Another observation made in this connection was the effect of increasing the duration of heating. As for example in the case of malon-p-chloranilic acid only 14.87% of it was formed when p-chloraniline and ethyl malonate mixture was heated for 30 minutes only, but it rose to 57.01% with 3 hrs. heating. Rapid heating on the other hand was found to be unfavourable, since it brought about the decomposition of the products to some extent. Similar observations were made in the cases of the two other isomers also. Effect of varying the duration of heating and the variation of temperature is clearly shown in Tables II, III and IV.

EXPERIMENTAL

The general procedure had been to mix 12 g. of freshly distilled chloraniline and 25 g. of diethyl malonate in a round bottomed flask and to reflux for nearly 2 to 3 hrs. The alcohol formed was allowed to escape. On cooling, rectified spirit (50 c. c.) was added. The flask was shaken well and kept aside for 10 minutes. The dichloro malon dianilide separated out and was filtered, which was further purified by recrystallization from alcohol. To the filtrate which contained the mono ester of the acid, 50 c. c. of 20% acqueous solution of sodium carbonate was added and then steam was blown through it for 30 minutes. The solution on cooling was filtered free of any dichloro malon dianilide separated during hydrolysis and then acidified with hydrochloric acid. The precipitated acid was filtered and purified by recrystallization from alcohol.

All the products obtained were white crystalline substances and their identity established by suitable estimations.

Table I gives the names of the products, with their melting points, chlorine contents, etc. Tables II, III and IV give the experimental conditions observed and the yield (%) of the products formed, from o-chloraniline, m-chloraniline and p-chloraniline respectively.

TABLE I

No.	Name	Molecular Formula	m. p.	Eq. wt. Found	Eq. wt. Calculated	Chlorine % Found	Chlorine % Calculated
1.	Malon-o-chloranilic acid	$C_9H_8O_3NCl$	146°C(d)	214.3	213.56	16.15	16.60
2.	o, o-dichloro malondianilide	$C_{15}H_{12}O_2N_2Cl_2$	170°C			21.82	22.06
3.	malon-m-chloranilic-acid	$C_9H_8O_3NCl$	126°C(d)	212.3	213.56	16.70	16.60
4.	m, m-dichloro malondianilide	$C_{15}H_{12}O_2N_2Cl_2$	173°C			21.98	22.06
5.	malon-p-chloroanilic acid	$C_9H_8O_3NCl$	158°C(d)	214.4	213.56	16.51	16.60
6.	p, p-dichloro malondianilide	$C_{15}H_{12}O_2N_2Cl_2$	251°C			22.16	22.06

TABLE II

No.	o-chloraniline.	Ethyl malonate	Mol. Prop.	Time of heating (hrs.)	Yield % malon-o-chloranilic acid.	Yield % o,o-dichloro malon-dianilid
1.	12 g	25 g	1:1.5	0.5	2.5	2
2.	12	25	1:1.5	0.75	7.4	3.3
3.	12	25	1:1.5	1.00	14.5	5.9
4.	12	25	1:1.5	1.25	19.3	6.6
5.	12	25	1:1.5	1.5	29.8	9.9
6.	12	25	1:1.5	1.75	34.7	11.5
7.	12	25	1:1.5	2.00	42.1	11.5
8.	12	25	1:1.5	2.25	47.1	13.0
9.	12	25	1:1.5	2.5	49.6	13.1
10.	12	25	1:1.5	2.75	52.1	14.8
11.	12	25	1:1.5	3.00	54.5	14.8

TABLE III

No.	m-chloraniline	Ethyl malonate	Mol. Prop.	Time of heating (hrs.)	Yield % malon-m-chloranilic acid	Yield % m,m-dichloro-malon-dianilide
1.	12 g	25 g	1:1.5	0.5	12.3	6.5
2.	12	25	1:1.5	0.75	17.3	8.2
3.	12	25	1:1.5	1.00	22.3	11.5
4.	12	25	1:1.5	1.25	24.4	11.5
5.	12	25	1:1.5	1.5	32.2	13.1
6.	12	25	1:1.5	1.75	39.6	13.9
7.	12	25	1:1.5	2.00	47.0	13.9

TABLE IV

No.	p-chlor-aniline	Ethyl malonate	Mol-Prop.	Time of heating (hrs.)	Yield % malon-p-chloranilic acid	Yield % p, p-dichloro-malon-dianilide
1.	12 g	25 g	1:1.5	0. 5	14.8	6.5
2.	12	25	1:1.5	0.75	17.3	8.2
3.	12	25	1:1.5	1.00	24.4	8.2
4.	12	25	1:1.5	1.25	27.2	9.8
5.	12	25	1:1.5	1.5	29.7	9.8
6.	12	25	1:1.5	1.75	34.6	11.5
7.	12	25	1:1.5	2.00	44.6	11.5
8.	12	25	1:1.5	2.25	47.0	13.1
9.	12	25	1:1.5	2.5	49.5	14.7
10.	12	25	1:1.5	2.75	52.0	14.7
11.	12	25	1:1.5	3.00	57.0	14.7

SUMMARY

Malon-o-m- and p- chloranilic acids were prepared by the condensation of the respective chloraniline with ethyl malonate. Three other products isolated during these preparations were o, o-dichloro malon dianilide, m, m-dichloro malon dianilide and p, p-dichloro malon dianilide. Of these malon-o-chloroanilic acid and p, p-dichloro-malon-dianilide have been prepared by earlier workers. The others have now been prepared for the first time. Optimum conditions for the preparation of these compounds are reported.

The authors are grateful to the Ministry of Education, Govt. of India for the award of a Senior Research Scholarship to one of them (M.V.G.)

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THE CONDENSATION OF ALDEHYDES WITH β-KETO-ESTERS IN THE PRESENCE OF THREE DIFFERENT ORGANIC BASES
PART I.—OF SALICYLALDEHYDE AND NINE OF ITS DERIVATIVES WITH ETHYL ACETO-ACETATE*

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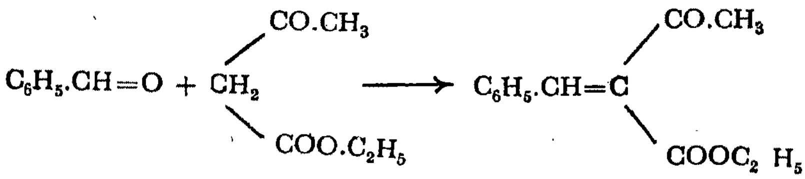
Abstract

Following the observation of the catalytic effect of pyridine in several condensations (e.g. of aldehydes with malonic acid, malonanilic and other related acids, by Pandya and coworkers), condensations of aldehydes with β-keto-esters have now been examined, in the presence of three bases. This paper deals with these condensations with ethyl aceto-acetate of salicylaldehyde and nine of its derivatives. The reactions accord with theory in the matter of yields and reaction velocities. Moreover, halogen-substitution increases yields and velocity of reaction as Cl> Br; mono-halides>di-halides. I-derivatives react very quickly, but decomposition also begins to start, and blackening takes place even at room temperature.

The reaction between an aldehyde, such as benzaldehyde and ethyl aceto-acetate, in the presence of a suitable catalyst, leading to the formation of benzylidene-ethyl aceto-acetate (1), is an example of Knoevenagel's reaction. It belongs to a general type in which a carbonyl group reacts with a reactive methylene group. The catalysts which Knoevenagel found effective are organic primary and secondary bases like aniline, diethylamine and piperidine. The object of the work described here was, not only to obtain the various condensation products, many of them quite new, but also to study the comparative efficacy of the three bases used, viz., piperidine, pyridine and 2:6-lutidine. Knoevenagel (9) believed that the organic base NH_2-R' or NHR'R″ first combines with the aldehyde to give intermediate products like R-CH (OH) NHR', R-CH$(NHR')_2$ and R-CH$(NR'R'')_2$ which then react with ethyl aceto-acetate regenerating the base.



$$C_6H_5.CH{=}O + \overset{CO.CH_3}{\underset{COO.C_2H_5}{CH_2}} \longrightarrow C_6H_5.CH{=}\overset{CO.CH_3}{\underset{COOC_2H_5}{C}}$$

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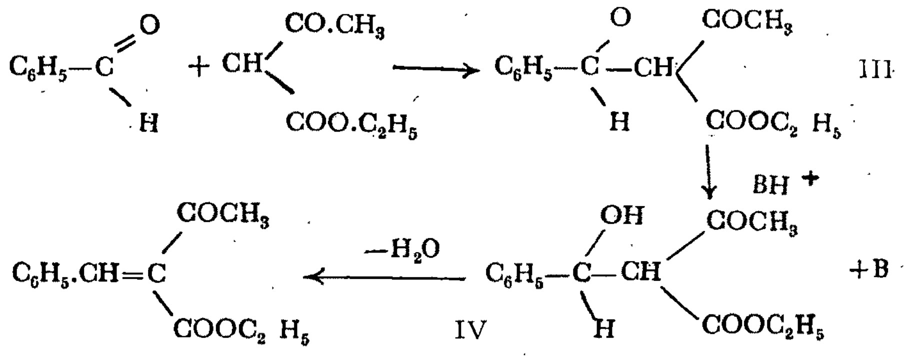
*Based on a paper read before the Indian Science Congress at Bangalore in 1951: vide Abstracts p. 85.

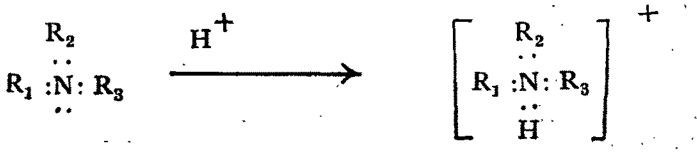
Although such intermediate products were actually isolated in some cases, Knoevenagel's mechanism will not hold in the case of a tertiary base, which cannot react with an aldehyde, but which is nevertheless found effective (though poorly) in this reaction (vide Experimental).

The correct mechanism of such a reaction, showing the base as the catalyst, was first given by Lapworth (11) and was subsequently confirmed by Arndt and Eistert (1) and by Hauser and Renfrow (5). The base B* accepts the incipiently ionised hydrogen of the reactive methylene group of a molecule of ethyl aceto-acetate or ethyl benzoylacetate, forming BH+ and the anion (II). The latter then adds to the aldehyde molecule forming the anion (III). The hydrogen ion then separates from BH+ and adds to (III) forming (IV) and regenerating the base. After the loss of water,

$$CH_3—CO—CH_2—COOC_2H_5 \longrightarrow CH_3.CO.\overset{\cdot\cdot}{C}H—COOC_2H_5 + BH+$$



(IV) gives 'bezylidene-*mono*-ethylaceto-acetate (I). In the light of the above mechanism, an organic base whether primary, secondary or tertiary, will accept a hydrogen ion from ethyl aceto-acetate, due no doubt to the lone pair of electrons on the nitrogen atom, which provides a seat for attachment.



$$R_1 :\overset{R_2}{\underset{\cdot\cdot}{\overset{\cdot\cdot}{N}}}: R_3 \xrightarrow{H^+} \left[R_1 :\overset{R_2}{\underset{H}{\underset{\cdot\cdot}{\overset{\cdot\cdot}{N}}}}: R_3 \right]^+$$

Now although every organic base has a lone pair of electrons on its nitrogen atom, the availability of this pair will be governed by the constitution of the base; in the saturated base piperidine the lone pair will always be available for the hydrogen ion to produce piperidonium cation (V): The case

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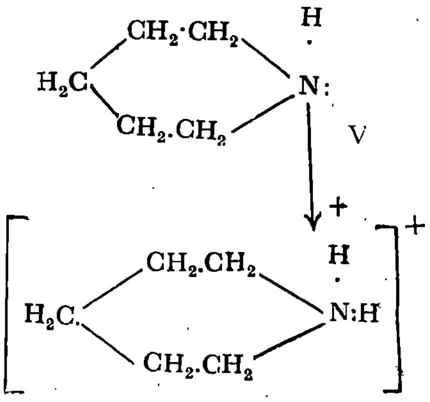
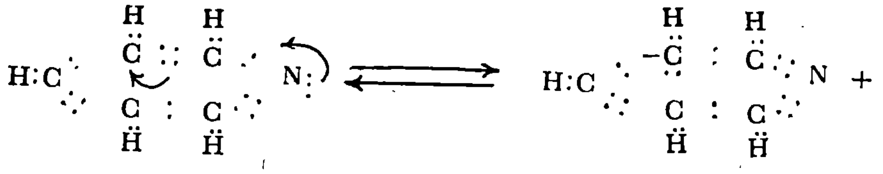
* A base is that which accepts hydrogen ion.



of pyridine is different. It is an example of "hetero-enoid" system, N-C=C, in which the lone pair of electrons on nitrogen appears to be in conjugation with the rest of the system (compare Robinson, 17).



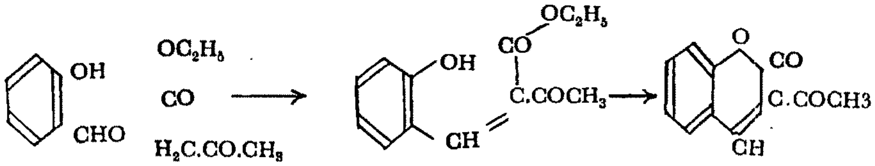
This limitation in the availability of the lone pair of electrons on nitrogen should therefore make pyridine less effective as a catalyst in comparison with piperidine. This limitation is to some extent compensated in α methylpyridine (α-picoline). The +I effect of the methyl groups will tend to create high electron-density on the neighbouring nitrogen in the same way as the methyl group of toluene does on the ortho carbon atom. In other words, α-methylpyridine is expected to be somewhat more effective as a catalyst than pyridine, although it will still remain less effective than piperidine. The same principle holds in the case of 2:6—dimethylpyridine (lutidine).

A comparison of the dissociation constants of the bases supports the above deductions :

Piperidine K — 1.58×10^{-3} at 25°
Pyridine K — 2.4×10^{-9} ,, ,,
2-Methylpyridine K — 3.2×10^{-8} ,, ,,
(The value for 2:6-dimethylpyridine is not available.)

It will be seen from the experimental part of the paper that the efficacy of the bases in Knoevenagel's reaction is in the order piperidine>2:6-lutidine> pyridine, in conformity with the above theoretical deductions.

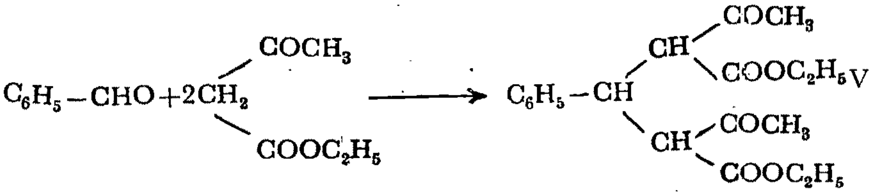
The aldehydes treated in this paper are salicylaldehyde and nine substituted derivatives. Salicylaldehyde gives here first *O*-hydroxybenzylidineethyl aceto-acetate (VI), which stabilises itself by cyclisation, with the loss of a molecule of alcohol, to 3-acetyl-coumarin [Knoevenagel, (9) and Experimental]. Pandya, Gupta and Dutta (4) got the same product while using pyridine, and Pandya and Miss Pandya (Junior) also obtained the same later while using lutidine.


VII

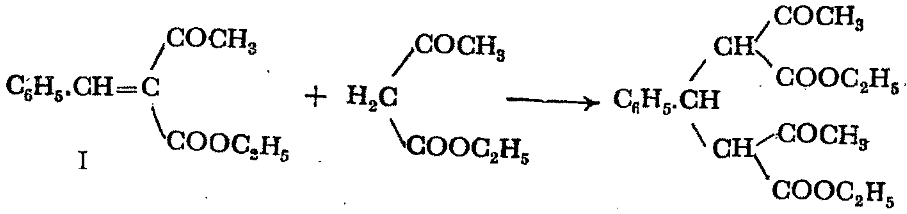
The substituted salicylaldehydes used here are (1) 5-chloro-, (2) 3:5-dichloro-, (3) 5-bromo-, (4) 3:5-dibromo-, (5) 5-iodo-, (6) 3:5-diiodo-, (7) 3-nitro-, (8) 5-nitro-, and (9) 4-hydroxy-salicylaldehydes: these give the respective reaction products (i) 6-chloro-3-acetylcoumarin, (ii) 6:8-dichloro-3-acetylcoumarin, (iii) 6-bromo-3-acetylcoumarin, (iv) 6:8-dibromo-3-acetylcoumarin, (v) 6-iodo-3-acetylcoumarin, (vi) 6:8-diiodo-3-acetylcoumarin, (vii) 8-nitro-3-acetylcoumarin, (viii) 6-nitro-3-acetylcoumarin and (ix) 7-hydroxy-3-acetylcoumarin. For each of the condensations, the three bases, piperidine, pyridine and 2:6-lutidine were used separately as the catalysts, and the effectiveness of each base, as measured by the yeild of the reaction product as well as by the time of the reaction, came out as deduced above.

Of the 3-acetylcoumarins mentioned above, (i), (ii), (iv), (v), (vi), (vii) and (viii) are prepared here for the first time: also the coumarins (i), (ii), (iii), (iv) and (ix) have been characterised by the preparations of their respective oximes and by the determination of the melting-points of these. Of those reaction-products obtained by other workers before, 6-nitro-3-acetylcoumarin and 3-acetylumbelliferone were obtained by Wahlberg (18) and by Weiss and Mercksammer (19) respectively, by totally different methods.

With excess (two molecules) of ethyl aceto-acetate, benzaldehyde reacts to give benzylidene-*bis*-ethylacetoacetate (VIII).


VIII

All other aldehydes, excepting salicylaldehyde and its substituted derivatives (such as are described in the present paper), give this kind of products (VIII) which are really the *bis*-compounds. The reason for this difference between salicylaldehydes and the other aldehydes is obvious. In benzylidene-*mono*-ethylaceto acetate (I) formed from one molecule of the ester and one of the aldehyde, the ethylenic bond between the carbon atoms is activated in the same way as in ethyl cinnamate, and Michael addition of the second molecule of ethyl acetoacetate follows (8). The same catalyst which brings about the formation of (I) does also that of (VIII) from (I).



$$\underset{\text{I}}{C_6H_5.CH{=}C(COCH_3)(COOC_2H_5)} + H_2C(COCH_3)(COOC_2H_5) \longrightarrow \underset{\text{VIII}}{C_6H_5.CH[CH(COCH_3)(COOC_2H_5)]_2}$$

With Salicylaldehyde, the (VI) is first formed as usual, but the conditions of cyclisation to acetylcoumarin are so favourable that this gains ground over the Michael addition. A second molecule of the ester has therefore no effect, beyond somewhat improving the yield of the first reaction. This cyclisation is possible only in the cases of 2-hydroxybenzaldehyde and derivatives.

EXPERIMENTAL

The general procedure was to mix the aldehyde with ethyl aceto-acetate (1 : 1 or 1 : 2 mols.) and to add the minimum amount of absolute alcohol to get a clear solution. Piperidine (0. 1 mol.), dissolved in absolute alcohol (3:8 by volume), was then added (in two instalments usually), allowing the mixture to stand at room temperature for some time after each addition. [This procedure is according to Horning and Chain, (7); Knoevenagel (10) used alcohol for vanillin only.]

With pyridine and 2:6-lutidine, the procedure was to mix the aldehyde and the ester (1:1 or 1:2 mols), and then add the base (pyridine 6 mols. and lutidine 3 mols). The contents had to be heated on water-bath for 5 to 10 hours, or more if necessary.

The reaction mixture was then treated with dilute acetic (or very dilute hydrochloric) acid and filtered. The solid product was then washed with cold water and dried. It was then recrystallised from acetic acid.

Condensation of Salicylaldehyde.—The following table (Table I) gives the yields of 3-acetylcoumarin (VII) obtained by using separately the three bases. The 3-acetylcoumarin melted at 123° [120°, Knoevenagel, (9); 123° Rap, 1897 (16).]

TABLE I

No.	Base	Molar proportion	Temp.	Time	Percentage yield
1	Piperidine	1 : 1 : 0·15	17°	6 hours	77·7 (Gupta, Dutt, Pandya) (4)
2	,,	1 : 2 : 0·15	23°	$^3/_4$ hour	88
3	Piperidine solution	1 : 1 : 0·1	17°	10 minutes	100
4	,, ,,	1 : 2 : 0·1	21°	30 minutes	100
5	Pyridine	1 : 1 : 6	80°—90°	24 hours	35 (Gupta, Dutt, Pandya) (4)
6	,,	1 : 1 : 6	Water bath	24 ,,	38
7	,,	1 : 1 : 6	,,	48 ,,	30
8	2 : 6 lutidine	1 : 1 : 3	,,	20 ,,	56
9	,,	1 : 1 : 6	,,	20 ,,	51
10	,,	1 : 2 : 3	,,	20 ,,	58

Condensation of 5-Chlorosalicylaldehyde :—

5-Chlorosalicylaldehyde (1) was prepared by the method of Biltz and Stepf (2) as modified by Nigam and Pandya (14). It melts at 101°. 6-Chloro 3-acetylcoumarin (i) (in long pale needles) melts at 206°. (Found Cl=16.18, $C_{11}H_7O_3Cl$ requires Cl =15.97 3 %.) The oxime melts at 226° (decomp).

TABLE I

No.	Base	Molar proportion	Temp.	Time	Percentage yield of (i)
1	Piperidine solution	1 : 1 : 0·1	28°	45 minutes	87
2	,,	1 : 1 : 0·1	28°	40 ,,	89
3	,,	1 : 2 : 0·1	15°	30 ,,	100
4	Pyridine	1 : 1 : 6	Water bath	5 hours	53
5	,,	1 : 1 : 6	,,	10 ,,	43
6	,,	1 : 2 : 6	,,	5 ,,	50
7	,,	1 : 2 : 6	,,	10 ,,	52
8	2 : 6 lutidine	1 : 1 : 3	,,	5 ,,	80
9	,,	1 : 1 : 3	,,	10 ,,	33
10	,,	1 : 2 : 3	,,	5 ,,	38
11	,,	1 : 2 : 3	,,	10 ,,	25

Condesnation of 3:5-Dichlorosalicylaldehyde (2) :—

The aldehyde was prepared by the method of Biltz and Stepf, (2) as modified by Nigam and Pandya (14). It melts at 95°.

6:8-Dichloro-3-acetylcoumarin (ii) (in white thin needles) melts at 175°. (Found Cl=27·84, $C_{11}H_6O_3Cl_2$ requires=27.62 %). Its oxime melts at 185° (dec.).

TABLE III

No.	Base	Molar proportion	Temp.	Time	Percentage yield of (ii)
1	Piperidine solution	1 : 1 : 0·1	28°	48 hours	79
2	„	1 : 2 : 0·1	„	26 „	81
3	„	1 : 2 : 0·1	17°	16 „	88
4	Pyridine	1 : 1 : 6	Water bath	5 „	48
5	„	1 : 2 : 6	„	5 „	40
6	2 : 6 lutidine	1 : 1 : 3	„	5 „	71
7	„	1 : 2 : 3	„	5 „	68

Condensation of 5-Bromo-salicylaldehyde (3) :—

The aldehyde was prepared by direct bromination by the method of Pandya and Miss Pandya (15). It melts at 105°.

6-Bromo-3-acetylcoumarin (iii) melts at 219° [Linch, (12) gives the m.p. 217°]. Its oxime melts at 220° (dec.).

TABLE IV

No.	Base	Molar proportion	Temp.	Time	Percentage yield of (iii)
1	Piperidine solution	1 : 1 : 0·1	28°	50 minutes	62·5
2	„	1 : 2 : 0·1	„	30 „	89
3	„	1 : 2 : 0·1	17°	15 „	98
4	Pyridine	1 : 1 : 6	Water bath	5 hours	36
5	„	1 : 2 : 6	„	5 „	32
6	2 : 6 lutidine	1 : 1 : 3	„	5 „	58
7	„	1 : 2 : 3	„	5 „	49

Condensation of 3:5-Dibromo-salicylaldehyde (4) :—

It was prepared by direct bromination of salicylaldehyde by the methed of Pandya and Miss Pandya, (15). It melts at 84°. 6:8-Dibromo-

3-acetylcoumarin (iv) (in pale yellow long needles) melts at 222°. (Found Br.=46.42, $C_{11}H_6Br_2$ requires Br=46.4 %). The oxime melts at 209° with decomposition.

TABLE V

No.	Base	Molar proportion	Temp.	Time	Percentage yield of(iv)
1	Piperidine solution	1 : 1 : 0·1	28°	30 hours	84
2	„	1 : 2 : 0·1	„	20 „	97
3	„	1 : 2 : 0·1	17°	4 „	100
4	Pyridine	1 : 1 : 6	Water bath	5 „	50
5	„	1 : 2 : 6	„	5 „	34
6	2 : 6 lutidine	1 : 1 : 3	„	5 „	52
7	„	1 : 2 : 3	„	5 „	41

Condensation of 5-Iodosalicylaldehyde.

This aldehyde (5) was prepared by the method given by Bougault, Cattlelain, Chabrier and Quevanviller (3) for preparing the 3:5—diiodoaslicylaldehyde; only in the present case the amount of iodine taken was exactly half the amount used in the preparation of the di-iodo derivative. The 5-iodosalicylaldehyde melted at 102° [Heilbron gives the same m.p.]. 6-Iodo-3-acetylcoumarin (v) in tiny yellow needles, melted at 238°, decomposition starting at 226°. (Found I=40·03 $C_{11}H_7O_3I$ requires I=40.44%).

TABLE VI

No.	Base	Molar proportion	Temp.	Time	Percentage yield of (v)
1	Piperidine solution	1 : 1 : 0·1	28°	Immediate solidification	94
2	„	1 : 1 : 0·1	„	„	98
3	Pyridine	1 : 1 : 3	75-80°	2·5 hours	46
4	„	1 : 2 : 3	„	„	40
5	Lutidine	1 : 1 : 3	„	1·5 hours	56
6	„	1 : 2 : 3	„	1·5 „	52

Condensation of 3:5-Diiodosalicylaldehyde.

This aldehyde (6) was prepared by the method described above (Bougault and coworkers) (3). It melted at 108°. The condensation product, 6:8-

diiodo-acetyl-coumarin (vi), in stout yellow needles, melted completely at 252°, the decomposition starting at 244°. (Found I=57.60%, $C_{11}H_6O_3I_2$ requires I=57.72 %).

TABLE VII

No.	Base	Molar proportion	Temp.	Time	Percentage yield of(vi)
1	Piperidine solution	1 : 1 : 0·1	28°	30 minutes	80
2	,,	1 : 2 : 0·1	,,	20 ,,	86
3	Pyridine	1 : 1 : 3	75-80°	2·5 hours	44
4	,,	1 : 2 : 3	,,	,,	42
5	Lutidine	1 : 1 : 3	,,	1·5 ,,	50
6	,,	1 : 2 : 3	,,	,,	49

Condensation of 3-Nitro-salicylaldehyde (7):—

3-As well as 5-nitro-salicylaldehyde (7+8) were obtained from salicylaldehyde by the method of Miller; and (13), 3-nitro-salicylaldehyde melts at 118°, the 5-nitro-product melts at 126°.

8-nitro-3-acetylcoumarin (vi) obtained (in long yellow needles) from (7) melts at 210°. (Found N=5.87, $C_{11}H_7O_5N$ requires N=6.0%).

TABLE VIII

No.	Base	Molar proportion	Temp.	Time	Percentage yield of(vii)
1	Piperidine solution	1 : 1 : 0·1	15°	10 hours	54
2	,,	1 : 2 : 0·1	,,	3 ,,	60
3	Pyridine	1 : 1 : 6	Water bath	12 ,,	30
4	,,	1 : 2 : 6	,,	12 ,,	22
5	2 : 6 lutidine	1 : 1 : 3	,,	10 ,,	42
6	,,	1 : 2 : 3	,,	10 ,,	38

6-Nitro-3-acetylcoumarin (vii) obtained (in yellow needles) from (8) melts at 194°. (Found N 5.96, $C_{11}H_7O_5N$ requires N=6.0%).

TABLE IX

No.	Base	Molar proportion	Temp.	Time	Percentage yield of (viii)
1	Piperidine solution	1 : 1 : 0·1	15°	6 hours	64
2	„	1 : 2 : 0·1	„	2 „	68
3	Pyridine	1 : 1 : 6	Water bath	10 „	38
4	„	1 : 2 : 6	„	10 „	20
5	2 : 6 lutidine	1 : 1 : 3	„	10 „	46
6	„	1 : 2 : 3	„	10 „	40

Condensation of 4-Hydroxy-salicylaldehyde (β-resorcylic aldehyde) (9):—

7-Hydroxy-3-acetylcoumarin (ix) (obtained in yellow needles) melts at 236° with decomposition. Weiss and Mercksammer (19) give m. p. 236°].

The oxime melts at 252°C (dec.).

The compound dissolves in usual organic solvents giving blue fluorescence. The solutions become green on addition of glacial acetic acid. In the latter solvent alone it forms a green solution. It also decolourises alkaline potassium permanganate. These properties are characeristic of umbelliferone and its derivatives.

TABLE X

No.	Base	Molar proportion	Temp.	Time	Percentage yield of (ix)
1	Piperidine solution	1 : 1 : 0·1	15°	8 days	34
2	„ $+CO_2$	1 : 1 : 0·1 (CO_2 for 45 min.)	15°	4 „	58
3	Piperidine solution	1 : 1 : 0·1	—5°	24 hours	76
4	„	1 : 2 : 0·1	—5°	24 hours	78·6
5	Pyridine	1 : 1 : 6	15°	6 weeks	26
6	2 : 6 lutidine	1 : 2 : 6	15°	7 weeks	38

In the above condensations much resin was formed. To avoid this, attempt was made to replace air by an inert gas like carbon dioxide. But the best results were obtained by working at low temperature (-5°C).

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THERMAL EXPANSION OF ISOTROPIC CRYSTALS

COMPARISON OF GRUNEISEN'S THEORY WITH EXPERIMENTAL DATA

By S. S. SHARMA, M. Sc., Ph. D., P. E. S., *Professor of Physics, Government College, Gyanpur, U. P.*

ABSTRACT

The existing data of thermal expansion of eighteen monatomic crystals have been critically examined in the light of the Gruneisen's theory. Nine of these crystals (copper, silver, aluminium, gold, lead, platinum, iridium, nickel and palladium) belong to the face-centred cubic lattice; seven (iron, tantalum, molybdenum, tungsten, lithium, sodium and niobium) belong to the body-centred lattice structure and the remaining two are diamond and silicon. It has been shown that their thermal expansion shows marked deviations from the Gruneisen's law. This failure is specially noticeable in the case of body-centred lattices. The study reveals both the temperature as well as the frequency dependance of the Gruneisen's constant. Both of these results are contradictory to the well-known postulates of the Gruneisen's theory.

INTRODUCTION

According to Gruneisen's theory (22) the coefficient of cubical expansion of a crystal is given by the relation

$$\beta = \frac{K^{\circ}}{V_{o}} \frac{C_{v}}{\left[1 - \frac{m+n+3}{6} \cdot \frac{K^{c}\gamma E]}{V_{o}}\right]^{2}}$$

$$\text{or} = \frac{C_{v}}{Q^{\circ}\left[1 - k\frac{E}{Q^{\circ}}\right]^{2}}$$

where Cv is the molar specific heat at constant volume; Q° is a constant given by $\frac{V^{\circ}}{\gamma K^{\circ}}$ (Vo is the molecular volume and Ko the compressibility, both at absolute zero of temperature and pressure, γ is the Gruneisen's constant given by $-\frac{\partial \log v}{\partial \log v}$); E is the thermal energy given by the integral $\int_{0}^{T} C_v \, dT$ and k replaces $\frac{m+n+3}{9}$ and is thus related to exponents of the attractive and repulsive forces in atoms. According to the Gruneisen's theory k should have values lying between 2 and 3.

The Gruneisen constant appearing in Qo and the constant k are both semi-empirical constants. It is, therefore, usual to select them empirically in comparing the Gruneisen theory with experimental values of thermal expansion. The fact that the theoretical basis of Gruneisen's relation involves the assumption of a single Debye characteristic temperature has led to a tendency to calculate E by means of Debye functions. This is not justifiable since the specific heats do not always follow the Debye functions accurately. It is for this reason that the otherwise interesting work of Nix and MacNair (36, 37) cannot be considered to be a convincing proof of the above relation. These authors show that for some metals the coefficients of expansion agree with the above equation provided that Qo is chosen arbitrarily, and E is calculated from the Debye function with a suitably chosen value of Θ. It is, however, sometimes necessary to make slight adjustments to the value of Θ obtained from specific heat data. Sometimes it is also necessary to assign an arbitrarily chosen value for k for which there appears to be no theoretical justification. For instance, in the case of palladium these authors assign for k a value equal to 0.49; while for tungsten $k=30.63$. Thus, from the procedure adopted for selecting the constants, it is obvious that small deviations from Gruneisen's theory may not be easily detected and that only striking discrepancies will come to notice, and consequently although the conclusions of Nix and MacNair are of considerable interest, they do not constitute a proof of the above relation.

In this paper the existing data on thermal expansion of a number of isotropic crystals in relation to Gruneisen's theory are reviewed critically and discussed in relation to their structure.

1. *Copper*. The thermal expansion of this metal from room temperature to about 800° C. has been studied by Henning (23), Uffelman (49), Eucken and Dannohl (18) and Rosenbohm (41). The low temperature region has been investigated by Henning (*l. c.*), Dorsey (12), Buffington and Latimer (7), Keesom and collaborators (30), Simon and Bergmann (44), Adenstedt (1), and Aoyama and Ito (3). Nix and MacNair have studied its thermal expansion from —185° C. to 500° C.

Simon and Bergmann's data, which extend from – 180°C. to 0° C. deserve special mention. They found that their values did not fit in with Gruneisen's theory, which gave for the coefficient of expansion about half the experimental value at 95°K. According to Nix and MacNair, whose experimental results are in fair agreement with those of other workers, the values reported by Simon and Bergmann are much too high at room temperature and too low at 95°K. Such enormous discrepancies have not been confirmed by any other workers.

It is worth mentioning that Nix and MacNair's values at high temperatures are not in exact agreement with the lattice spacing measurements of Hume-Rothery and Andrews (26).

Adenstedt has tested Gruneisen theory in the low temperature region by taking Qo$=120$ Kcals; $\Theta=315$; $k=2.8$. According to Nix and MacNair, Qo$=120$ Kcals; Θ 325 and $k=2.8$. The choice of this characteristic temperature involves a difference of nearly 5% from the observed values of Giaque and others (1941), according to whom $\Theta=312.8$. It may be remarked that Nix and MacNair have employed the same values of the constants as used by Gruneisen himself (22). According to Hume-Rothery (26) if the actual values of observed specific heat are employed, the values of Qo$=117$ Kcals; $k=2.63$. Hence the choice of these constants by earlier workers appears to be reasonable.

The experimental data of Keesom and coworkers extend down to 20° K and thus afford a test of Gruneisen's theory at very low temperatures. For this purpose the ratio of α/C_V is evaluated and entered in the following table. The mean values of C_V in the ranges of temperature for which α values have been reported, are calculated from Giaque's paper (*l. c.*)

TABLE I. The ratio α/Cv for copper (20°K-273°K).

Temp. range (°K)	$\alpha.10^6$	C_v	$\alpha/C_v.10^6$
20/88	4.9	1.77	2.78
88/170	12.1	4.29	2.83
170/273	15.4	5.48	2.81

Thus the ratio α/C_V is practically constant.

2. *Silver.* Nix and MacNair's data in the range -186°C. to 25°C for this metal are in fair agreement with the previous determinations of Henning (23); Dorsey (12, 13), Buffington and Latimer (7), and Ebert (14). The values of Ebert extend to 48°K. It may be mentioned that in the case of this metal the lattice spacing measurements of Jay (29); and Hume-Rothery and Reynolds (28) are in exact agreement with the macroscopic measurements.

The data of Nix and MacNair are very closely explained by the constants, Qo$=109$ Kcals; $\Theta=215$ and $k=2.42$, while Ebert's values are Qo$=112$ Kcals; $\Theta=223$; $k=3.2$. His values show an excellent agreement except at 48°K where the discrepancy is 9%. The value of Θ from Giaque's work is 212.7. According to Hume-Rothery (26), Qo$=108$ Kcals and $k=3.07$ if experimental values of C_V are employed.

Keesom and collaborators (30) have studied the thermal expansion in certain ranges of temperature. Their values for the same, together with the experimental values of Giaque for specific heats, are entered below and the ratio α/C_V calculated.

TABLE II. The ratio α/C_V for silver (20°K-273°K).

Temp. range (°K)	$\alpha.10^6$	C_V	$\alpha/C_V.10^6$
20/90	9.8	2.49	3.94
90/171	15.9	5.06	3.14
171/273	17.6	5.70	3.09

Here the discrepancy is far too great to be covered by experimental errors. Lindemann's values (34) for α of this metal in the ranges of temperature (20-80)° K and (81-292)° K are respectively 8.8×10^{-6} and 15.5×10^{-6}. Taking C_V values from Giaque's paper, 2.34 and 5.20 respectively, the ratio α/C_V comes out to be 3.76×10^{-6} and 2.98×10^{-6} respectively. Thus the failure of the theory in this case appears to be genuine at these very low temperatures.

3. *Aluminium.* Earlier measurements from room temperature to 700°K have been made by Henning (*l. c.*), Hindert (24), Uffelman (*l. c.*) and Taylor and coworkers (48). In the low temperature region, measurements have been made by Henning, Buffington and Latimer, and Ebert whose values go down to 48°K. Nix and MacNair's values extend from −191°C. to 393°C. They have found that the thermal expansion of this metal can be accurately explained by Gruneisen's relation if the constants are assumed to be: $Q_0=83.6$ Kcals, $\Theta=400$; $k=2.7$. The characteristic temperature from the latest measurements of Giaque is 389.1. The constants used by Ebert, however, are $Q_0=86.1$; $\Theta=381$; $k=2.7$. There is excellent agreement between the experimental and calculated values of Ebert except at 48°K where the difference amounts to as much as 20%. It may be mentioned that the specific heat values used by him do not differ from Giaque's experimental values by more than 3-4% in the whole temperature region studied by him.

Thus the discrepancy in the lowest temperature region appears to be genuine as in the case of silver. Lindemann's values (*l. c.*) for α of this metal in the ranges of temperature (20-81)°K and (82-293)°K are 2.8×10^{-6} and $16.7-10^{-6}$ respectively. By taking C_V values from Giaque's work, 1.20 and 4.09 in the same range, the ratio α/C_V thus comes out to be 2.33×10^{-6} and 4.08×10^{-6} respectively which indicates that this metal does not follow Gruneisen's relation even approximately at very low temperatures.

At high temperatures as well, the Gruneisen's relation is not obeyed in the case of aluminium. For this purpose the following extract is quoted from Wilson's paper (51), which describes the lattice expansion measurements of this metal extending upto about 600° C.

"......The 'law' is not obeyed at high temperatures. For aluminium the ratio α/C_p at 0° C is 3.88; at 600°C it is 4.62. It may be concluded, therefore, since the remainder of the argument is purely thermodynamical, that the assumptions on which the Debye theory is based are not satisfied by aluminium in the temperature range covered by this work."

4. *Gold.* In the low temperature region the thermal expansion of gold has been studied by Dorsey (*l. c.*) Gruneisen (21), and Ebert (*l. c.*). The data of the last work extend to 48° K. At high temperatures the data of Austin (4), and of Esser and Eusterbrock (17) are available from room temperature. Nix and MacNair's values cover a range from —187° C to 730° C and are in good agreement with the previous workers. They find that their data can be adequately interpreted by the above formula if Qo=148.8 Kcals; $\Theta=190$ and k=3.4. Gruneisen (22) has explained his own data on gold and those of Dorsey by assuming Qo=145; $\Theta=190$ and k=3.0. Ebert has used exactly the same constants as Gruneisen. There is, however, a discrepancy of about 12% between the observed and calculated values of Ebert at 48° K. A deviation of 10% is also noticeable in the experimental and calculated mean values of expansion in the range $-190/-253°$ C. It may be mentioned that the experimental values of specific heat by Clusius and Harteck (9) do not differ very much from those given by $\Theta=190$ in the temperature range studied by these workers.

5. *Lead.* The earlier measurements are those of Dorsey, Gruneisen, and Ebert. According to Ebert whose data extend to 48° K, the values of α are very satisfactorily explained by the constants: Qo=79.6; $\Theta=92;=k=3.2$. The interferometric studies of Nix and MacNair are in fair agreement with the other workers. Their values cover a range $-188°$ C to 25° C. Their constants are: Qo=77.8; $\Theta=88$; k=3.19. According to Giaque $\Theta=930$.

As in the case of other metals, Lindemann's values are available in certain ranges of temperature down to 20° K. According to him the mean values of α in the range $(20—\Theta 81)°$K and $(83\Theta=292)°$K are 18. 80×10^{-6} and $26.50\times\Theta=10^{-6}$ respectively. Taking 4.15 and 6.05 as the mean values of C_v in the same range, the ratio α/C_v comes out to be 4.53×10^{-6} and 4.38×10^{-6} which is well within the limits of experimental error.

At high temperature, however, the results of Stokes and Wilson (47) do not confirm Gruneisen's law. These authors have investigated the lattice expansion of this metal from 0° – 320°C. According to them, "The coefficient of expansion increases about two and one half times as fast as the heat capacity, as shown in the following comparison:—

	0°C	100°C	200°C	300°C
$\alpha(t)/\alpha(_o)$	1.000	1.084	1.168	1.252
$C_p(t)/C_p(_o)$	1.000	1.038	1.064	1.096

Thus Gruneisen's relation is not obeyed by this metal above the room temperature.

6. *Platinum.* Gruneisen (22) explained the data of Henning (*l. c.*) and those of Valentiner and Wallot (50) by assuming the constants: Qo=231;

$\Theta=230$; $k=4.8$. The experimental value of $\Theta=225$. The value of k is higher than postulated by theory. Nix and MacNair, however, remark that their values for thermal expansion are in very poor agreement with those of the above workers, though they are in fair agreement with those of Dorsey (*l. c.*). The assign to these constants the values: $Q_o=22$; $\Theta=230$; $k=2.21$.

Here it is worth noting how inaccurate values for the thermal expansion can be reconciled with the theoretical formula by assuming an arbitrarily chosen value for k.

7. *Iridium.* The data of Valentiner and Wallot (*l. c.*) were explained by Gruneisen by assuming: $Q_o=307$; $\Theta=283$; $k=6.5$ (Θ experimental $=285$).

Here again the value for k is very high; even higher than that assigned in the case of platinum. But as Nix and MacNair's observations on the thermal expansion of platinum did not fit with those of Valentiner and Wallot, it is very likely that more accurate determinations for iridium might yield a more reasonable value for k.

8. *Iron and Nickel.* Iron has been studied in the low temperature region by Dorsey (*l. c.*); Ebert (*l. c.*); and Adenstedt (*l. c.*). The latter two workers have correlated their values with the Gruneisen theory. According to Ebert: $Q_o=145$; $\Theta=400$; $k=3.8$. Austin and Pierce (5), while investigating the thermal expansion of iron at high temperatures, remark: "By taking the same constants as used by Ebert in the low temperature region, we find that the calculated coefficients of expansion at high temperatures are in very poor agreement with those observed ...."

Adenstedt, on the other hand, gives the constants as $Q_o=166.7$; $\Theta=420$; $k=3.7$. Nix and MacNair whose measurements cover a range from -181°C to 685°C find that by taking the same constants as those of Adenstedt there is a good fit upto the room temperature but thereafter there is absolutely no fit due to disappearance of ferromagnetism in this region.

In the case of nickel, Nix and MacNair whose data cover a range from -192°C to 490°C give the constants: $Q_o=151.5$; $\Theta=410$; $k=4.0$ from experimental values is 375. As in the case of iron, there is no fit in the Curie-point region. But from the curves reproduced in their paper it is at once apparent that there is much better agreement between the experimental and theoretica curves for thermal expansion in the case of nickel than in the case of iron.

9. *Palladium and Tantalum.* The data of Nix and MacNair for palladium from -187°C to 26°C are explained by: $Q_o=163.7$; $\Theta=300$; $k=0.49$. The only other study of thermal expansion for this metal at low temperatures contains data at one temperature only. Henning (*l. c.*) reports a mean value of thermal expansion from 16°C to -191°C which is in good agreement with the value obtained by former workers.

For tantalum the previous value of Disch (11) at $-78°C$ is nearly 8% lower than the value obtained by Nix and MacNair whose studies cover a temperature range from $-181.5°C$ to 28°C. They give the constants: $Qo=292.4$; $\Theta=252$; $k=0.29$. The value of Θ from experimental data is 245.

From a perusal of the values of k for these two metals it is evident that a surprisingly low value has been employed for explaining the observed thermal expansion using Gruneisen relation. Remembering that, according to theory, k should lie between 2 and 3, the choice in these cases is unjustifiable. The Gruneisen formula can, therefore, only be regarded as an interpolation formula in this case.

10. *Molybdenum.* Nix and MacNair have studied the thermal expansion of molybdenum from room temperature to $-187°C$. Their values at $-78°C$ and $-190°C$ (extrapolated) are in fair agreement with those of Disch (11), who cites the values at these two temperatures only. The mean values between 0°C and 20°C and between 0° and Θ 183°C show a deviation of about 5% from Erfling's data (16). Nix and MacNair use the constants: $Qo=365$; $\Theta=388$; $k=6.83$. The experimental value of Θ is 380.

From this we see that the value of k is very high. The coincidence between the experimental and theoretical values is thus obtained fictitiously. In Table III below is given the ratio of $(l_{T_1}-l_{T_2})/l_{273}\cdot(E_{T_2}-E_{T_1})$, where l_T is the length of the specimen at T° K and E is the energy content already defined. For this purpose, $\frac{\Delta l}{l_o}$ has been directly read from the table given in Nix and MacNair's paper. The values of E have been taken from Landolt and Bornstein's Tables, which are based on the experimental results of Simon and Zeidler (46).

TABLE III. The ratio $\frac{\Delta l}{l_o\cdot\Delta E}$ for molybdenum.

Temp. range (°C)	$\frac{\Delta l}{l_o}\cdot 10^4$	ΔE	$\frac{\Delta l}{l_o\cdot\Delta E}\cdot 10^6$
25/0	1.350	140	9.64
0/-20	1.036	110	9.42
-49/-64	0.723	78	9.27
-64/-90.	1.205	131	9.20
-117/-143	0.964	113	8.53
-172/-187	0.361	43.5	8.29

Thus the ratio, as entered in the last column, goes on falling progressively with decrease in temperature and if the values were available beyond room temperature and below liquid air temperature, the discrepancy will obviously become more preponderent.

Recently Edwards and co-workers (15) have done high temperature work on the thermal expansion of some metals including molybdenum. By using the same constants as used by Nix and MacNair they have calculated the values of α from Gruneisen's theory. The following table is reproduced from their paper—

TABLE IV. Expl. and theoretical values of α for molybdenum.

Temp. (°K)	$\alpha . 10^6$ (Calculated)	$\alpha . 10^6$ (Observed)
1000	7.70	6.47
1200	8.35	6.89
1400	9.16	7.31
1600	10.07	7.73
1800	11.10	8.15
2000	12.47	8.57

Thus the same values of the constants which are made to give an exact fit at lower temperatures fail to give correct values at higher temperatures. This, therefore, represents a definite breakdown of Gruneisen's theory.

11. *Tungsten.* The early work on the thermal expansion of this metal by Fink (19), Langmuir (33), and Worthing (52) was primarily confined to filaments containing some 1% of thorium oxide as impurity. The work of Fink covered a narrow range of 20-100° C; while that of the latter workers was confined to a range 1000-2000° C. Disch (*l. c.*) studied the expansion of this metal of unknown purity from —190° C to 400° C. Later on Hindert and Sweeny (25) working with tungsten of 99. 98 % purity obtained accurate values for expansion from —100° C to 500° C.

Nix and MacNair, working in the range —171° C to 27.5° C, got the same value for expansion at —78° C as obtained by Disch, but there is a small difference between their results for the mean coefficients and those of Hindert and Sweeny. Accordingly to Nix and MacNair the constants are: $Q^\circ = 471.2$; $\Theta = 310$; $k = 30.63$.

Here we see that while in the case of tantalum one-tenth the theoretical value for k explains the observed thermal expansion data; in the case of tungsten a value ten times as great is needed. This again is a clear case in which Gruneisen's theory completely fails to explain the experimental data.

12. *Lithium.* The thermal expansion of this metal has been studied in the low temperature region by Simon and Bergmann (44) and the specific heat by Simon and Swain (45). The ratio α/C_V is entered in Table V:—

TABLE V. α/C_V for lithium.

Temp. (°K)	$\alpha \cdot 10^6$	C_V	$\alpha/C_V \cdot 10^6$
300	48.1	5.39	8.92
250	44.3	5.16	8.59
200	39.7	4.78	8.31
150	31.6	4.18	7.56
100	18.5	3.02	6.12

Thus we see that the ratio α/c_V falls so rapidly with decrease in temperature that a single value of k will not fit the whole data throughout the whole temperature range. The thermal expansion of this metal is, therefore, inexplicable on the basis of the above formula.

13. *Sodium.* Quimby and Seigel (38) have studied the thermal expansion of this metal in the range (80-290)° K and have shown that Gruneisen's law is obeyed accurately in this case. This they have done by calculating $(l_T - l_{273})/l_{273}\,(E_T - E_{273})$. But this ratio comes out to be reasonably constant only because the changes in length have been measured from 0° C. If, on the other hand, they are measured over shorter intervals of temperature, they show systematic deviations as shown in Table VI :—

TABLE VI. The ratio $\frac{\Delta l}{l_0 \cdot \Delta E}$ for sodium.

Temp. range (°K)	$\frac{\Delta l}{l_0} \cdot 10^5$	ΔE	$\frac{\Delta l}{l_0 \cdot \Delta E} \cdot 10^5$
80/90	41	51	0.80
100/120	101	111	0.91
140/180	239	240	1.00
220/260	271	251	1.05

14. *Niobium.* Thermal expansion measurements have been made very recently by Edwards and coworkers (15) in the range (100-25000)° K and they claim the verification of Gruneisen's theory but they do not mention the values of the constants chosen by them to secure this fit. They simply mention, "The constants used in the niobium calculations were determined by fitting our experimental data to the Gruneisen equation." Hence it is not possible to gauge the adequacy or otherwise of the choice of these constants in the case of this metal.

15. *Diamond.* The observed values of the mean coefficients of thermal expansion in the range (80-350)° K by Dembowska (quoted by Gruneisen, 22) have been explained by Gruneisen himself by assuming a value of $\gamma = 1.1$. Saksena (42), however, showed that though this value of the Gruneisen's constant gave a fairly satisfactory agreement between the observed and calculated

values of thermal expansion, it completely failed to fit Nayar's (35) spectroscopic observations on the frequency shift of the principal Raman line with temperature. He satisfactorily explained the discrepancy by classifying the frequencies in two groups and assigning each group with a different Gruneisen's constant. On this basis, the existing data of thermal expansion were also satisfactorily explained. Further the calculated values of α in the range 300-1100° K were found to be higher than those calculated by one constant (=1.1) as assumed by Gruneisen. This has been confirmed later by the experimental determinations of Krishnan (31, 32).

Dayal (10) deduced the separate Gruneisen constants for each frequency of the diamond lattice and showed that they varied from 0.82 to 2.00. His calculations also provided a theoretical justification for Saksena's results. By this Dayal not only satisfactorily explained the thermal expansion of diamond in the range 85-900° K but also explained Nayar's spectroscopic observation on the principal Raman line 1332.

16. *Silicon.* The thermal expansion of metallic silicon has been measured by Valentiner and Wallot (*l. c.*) in the range (100-250)° K and has been shown to exhibit an anomalous behaviour. Table VII gives the ratio α/C_p for this metal at different temperatures.

TABLE VII. α/C_p for silicon.

Temp. (°K)	$\alpha . 10^6$	C_p	$\alpha/C_p . 10^6$
280.6	2.53	4.71	0.54
202.2	1.49	3.77	0.39
134.6	0.28	2.53	0.11
100.3	-0.22	1.73	-0.13

The C_p values in this table have been calculated from Anderson's experimental data (2).

Simon and Bergmann (44), however, found that the thermal expansion of various specimens of silicon had different values. From this they inferred that the expansion depends on the previous history of the specimens. Actually, the coeffiicient of linear expansion varies within wide limits from 2.8 to 7.3×10^{-6} (I. C. Tables, Vol. I, p. 104). Unfortunately such interesting and important results are still unconfirmed; hence no definite conclusions as to the validity of Gruneisen's law can be drawn.

DISCUSSION

Out of sixteen cubic crystals (excluding diamond and silicon), thermal expansion data of which have been examined here in the light of

Gruneisen's theory, the following nine possess the face-centred lattice:—

Copper
Silver
Aluminium
Gold
Lead
Platinum
Iridium
Nickel
Palladium

The remaining seven metals, namely

Iron
Tantalum
Molybdenum
Tungsten
Lithium
Sodium
Niobium

belong to the body-centred cubic lattice.

From the above study it is obvious that the metals possessing the face-centred cubic lattice obey, as a general rule, the Gruneisen formula fairly satisfactorily above the liquid air temperature. Below this temperature the thermal expansion data are very meagre and practically in every case they are even unconfirmed. It may be added that for the body-centred metals no thermal expansion data are available below the liquid air temperature. Hence, the Gruneisen theory, unlike the specific heat theories, cannot be put to severe test upto the lowest possible temperatures. Out of the nine face-centred crystals, mean values for the coefficients of linear expansion extending over the wide range of temperature have been reported upto 20°K in the case of copper, silver, aluminium, gold and lead only. From the results already quoted in the foregoing pages it is seen that in the case of copper the Gruneisen formula satisfactorily explains the observed thermal expansion throughout the whole temperature range. In the case of lead the agreement is fairly close upto the room temperature, above which the ratio of thermal expansion to specific heat continuously rises with temperature. In the case of aluminium and silver the Gruneisen theory fails to explain the observed thermal expansion below the liquid air region. As in the case of lead, the lattice measurements of aluminium show that the ratio of thermal expansion coefficient to thermal capacity above the room temperature is not constant as demanded by theory. A 10% discrepancy between the observed and calculated values of thermal expansion is also noticeable in the case of gold in the range —190°C to —253°C.

The only exception where the thermal expansion data is inexplicable on Gruneisen's theory is palladium, where a very small value for k (=O.49) has been employed to explain the observed data. Such a low value is unwarranted from theoretical consideration.

The slight discrepancy between the experimental and theoretical values in the case of nickel can be partially accounted for by the complicated behaviour of this metal in the Curie-point region.

These considerations lead us to the inevitable conclusion that the values of the Gruneisen constants for the various frequencies above the liquid air temperature are so near eath other that an average value works fairly satisfactorily. The failure of the theory, however, in certain ranges of temperature seems to indicate that the Gruneisen constant does depend upon temperature in contradiction to the postulates of the theory.

In the case of the metals belonging to the body-centred type lattice, the theory is wholly unsuccessful in interpreting the experimental data of thermal expansion. It may be mentioned that in this respect the Gruneisen's theory follows the Debye theory of specific heats. It is a well-known fact that in the case of face-centred metals (gold being a striking exception), the specific heats are adequately given by a Debye function upto sufficiently low temperatures. It is only in the case of body-centred metals that the theory meets with difficulties (Dayal, 10). Although the existing data on thermal expansion in the case of metallic silicon are not conclusive, yet it appears highly probable that they are also inexplicable on the Gruneisen's theory.

As pointed above, Nayar's spectroscopic data on the variation of the principal frequency with temperature in the case of diamond cannot be explained if each frequency is assigned the same average value for γ as assumed by Gruneisen for explaining the thermal expansion in the low temperature region. Bhagwantam (6) and Chelam (8) by applying group theoretical considerations have obtained expressions for the normal modes of vibration of the diamond lattice on the basis of Raman theory (39; 40). The frequencies are 1332, 1284, 1248, 1149, 1048, 1013, 784, 565. The first six higher frequencies represent modes of vibration in which the distances between neighbouring carbon atoms alter and are mainly determined by the binding forces between them; whilst the lowest two frequencies do not involve any variation of the distance between the carbon atoms linked with each other and obviously these two groups should have different Gruneisen constants.

In the case of the present metals too specially those crystallising in the body-centred type structure, the failures of the Gruneisen theory seem to arise from the fact that the different vibration frequencies of the lattice have marked differences in their volume dependence with temperature, hence an average value of the Gruneisen's constant does not fit in the experimental data. The conclusion from the present study, therefore, is irresistible that these failures of the theory are intimately connected with the crystal structure and there appears to be no valid justification for taking a single value of γ for all the vibration frequencies.

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ATOMIC PARACHOR OF LITHIUM

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Sugden (4) pioneered the work on the determination of the parachor of atoms of inorganic elements. He assumed that the parachor value for a polar substance is the same as in case of semi-polar bond and hence attributes it a value of —1.6. Sugden and Willkins (5) have used the surface-tensions of fused salts as determined by Jaeger (2) at various temperatures to determine the parachor of fused salts and hence calculated the atomic parachor of alkali metals. The value thus obtained for lithium is 50. The method of calculation is as follows. From the observed parachor of a salt, the atomic parachors of the constituent atoms except lithium is subtracted, so also the value —1.6 for a semi-polar bond. The difference gives the value for the parachor of lithium.

These would need a revision because in fused state and at such a high temperature these salts ionise and hence we get the parachor of ions and not of atoms. This will be clear from the following table:—(Taken from the data supplied by Sugden 6).

Salt	Temp. in °C.	Parachor	Mean Parachor	$\Sigma(P)$	P_{Li}
LiF	855-1000	57.8-59.3	58.5	24.1	34.4
LiCl	600-755	97.2-99.6	98.4	52.7	45.7
$LiNo_3$	350-500	130-132.9	131.5	91.5	40.0
Li_2SO_4	860-1150	212-220	216.0	121.8	2×47.1

The average of all these values has been taken by Sugden (*loc. cit.*) as 50.0. We do not quite follow how the average of 34.4, 45.7, 40.0 and 247.1 can be 50.0. The second objection which has been raised by Mumford and Phillips (3) is that in fused conditions these substances ionise partly. The parachor in the fused condition is therefore partly due to ions.

We have determined the parachor of lithium salts in organic solvents where there is little possibility of ionisation. Thus following are our results.

N. B. In calculating the parachor of solute in solution the mixture law of Hammick and Andrew (1) has been applied. In the following tables:— x=Molecular fraction of lithium salt, t=Temperature in °C, d=Density of the solution, r=Surface tension, Pm=Parachor of the solution, and Px=The parachor of lithium salt.

Table I. Parachor of lithium chloride

Solvent	x	t	d	r	Pm.	Px (lithium chloride.)
Ethyl alcohol	0.019598	28.8	0.79823	22.6	124.98	96.60
	0.027852	26.0	0.80523	22.93	124.73	99.09
	0.029173	27.8	0.80457	22.83	124.73	99.176
	0.030895	23.6	0.80892	23.347	124.64	99.99
Ethyl acetate	0.025958	23.2	0.89661	23.044	211.15	102.86
	0.041631	23.6	0.89817	22.597	209.22	99.00
	0.051280	23.0	0.90049	22.953	208.21	100.66
	0.057553	23.6	0.90178	23.078	207.47	99.05
	0.059090	28.6	0.89229	22.146	207.33	100.51
Amyl alcohol	0.031100	25.3	0.81754	25.038	237.37	99.043
	0.043073	20.6	0.82369	25.675	235.58	98.671
	0.050923	20.4	0.82369	25.969	234.48	98.572
	0.054880	20.8	0.82672	26.009	233.92	98.942
	0.060073	24.4	0.82666	25.958	233.17	98.709
Methyl alcohol	0.020021	25.5	0.81334	24.119	87.728	99.098
	0.027749	25.2	0.82120	24.845	87.804	98.561
	0.032393	25.0	0.82438	25.164	87.852	98.419
	0.041869	28.6	0.82941	25.445	87.866	101.03

Table II. Parachor of lithium bromide

Solvent	x	t	d	r	Pm.	Pa. (lithium bromide)
Methyl-alcohol	0.010840	26.2	0.81034	22.651	87.759	111.71
	0.012595	27.8	0.81294	22.721	87.795	111.01
	0.013875	21.6	0.81959	23.310	87.824	111.02
	0.015311	22.6	0.82111	23.246	87.850	111.05
	0.016418	25.4	0.82073	23.129	87.887	111.32
	0.027343	19.3	0.84462	24.407	87.154	111.54
	0.015235	28.3	0.80457	21.846	125.48	111.58

TABLE II. Parachor of lithium bromide

Solvent	x	t	d	r	pm.	Pa. (lithium bromide)
Ethyl alcohol	0.022382	22.6	0.81824	22.685	125.18	111.69
	0.027135	21.2	0.82532	23.029	125.11	111.66
	0.027295	23.0	0.82206	22.707	125.11	111.74
	0.030279	25.0	0.82530	22.793	125.06	111.29
	0.054766	21.3	0.85713	24.132	124.72	111.37
Ethyl acetate	0.035277	28.6	0.90860	22.297	210.58	115.90
	0.041198	24.7	0.91681	22.960	209.99	115.54
	0.048042	19.7	0.92673	23.672	209.32	115.94
	0.049369	19.4	0.92907	23.854	209.18	115.66
	0.050150	24.4	0.92219	23.149	209.13	115.85
	0.062478	19.7	0.93654	24.055	207.90	115.72

The average parachor of lithium chloride and lithium bromide are 100.5 and 115.5 respectively when ethyl acetate is taken as solvent; while in case of alcohols as solvents the values come quite different and are not constant. Turner and Bisset (8) have found that these alcoholic solvents form additional molecular compounds with lithium halides; Following complexes of lithium chloride and bromide have been found by them:—

Salt	Complex with alcohol
LiCl	$LiCl.\ 3CH_3OH$
LiCl	$LiCl.\ 4C_2H_5OH$
LiBr	$LiBr.\ 3CH_3OH$
LiBr	$LiBr.\ 4C_2H_5OH$

It is natural to get values different in these solvents from the value we have observed in ethyl acetate, where there is neither complex formation nor dissociation. In fact the real values of the lithium compounds will be in this very solvent.

The parachor of Cl and Br in covalent compounds has been determined by Sugden (7). They are $P_{Cl}=54.3$ and $P_{Br}=68.0$ hence the parachor value of atomic lithium will be $P_{LiCl}-P_{Cl}=100.2-54.3=45.9$ and $P_{LiBr}-P_{Br}=115.5-68.0=47.5$.

Thus on an average the parachor of lithium atom comes to be 46.7 while Sugden found it to be 50.0 not very far off from our results.

ACKNOWLEDGMENTS

Authors wish to thank Dr. W. V. Bhagwat, Professor and Head of the department of Chemistry, Holkar College, Indore, for his keen interest and valuable guidance in the work.

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STUDIES IN IONIC EXCHANGE AFFINITIES: AFFINITY AND PARACHOR

By R. P. SHUKLA, R. P. BHATNAGAR and R. K. SHREEMAL, *Department of Chemistry, Holkar College, Indore.*

Preliminary considerations. Several approaches have been made to the physical chemistry of equilibrium cation exchange, (2,8,9) but no satisfactory results have been obtained as yet. Recently Boyd, Schubert and Adamson (2) studied the equilibrium conditions in a phenol sulphonate resin exchanger, Amberlite IR–1. Unfortunately, several unsatisfactory features mar the validity of this work. First, lithium appears to have been wrongly plotted. Secondly, the a° value used for sodium quoted from Brown and MacInnes (3) is 5.2 instead of 4.45. Thirdly, there appears to be an arithmetical error in the calculation of a° for ammonium chloride from the data quoted by Latimer. A recalculation gives a value of about 2 instead of 4.5. When these discrepencies are corrected, the points no longer lie on a straight line. The utility of this method is also restricted by the incompleteness as well as by the uncertainty of much of the existing data.

Kressman and Kitchener (6) have studied the cation exchange with a synthetic phenol sulphonate resin. According to them the equilibria are approximately represented by the law of mass action and the equilibrium constants for $Li^{\cdot}$; $H^{\cdot}$; $Na^{\cdot}$;$K^{\cdot}$ $Rb^{\cdot}$, and $Cs^{\cdot}$ are a function of the hydrated ionic size expressed as the a°, parameter in Debye-Huckel theory. But Kressman and Kitchener (6) also made an error by estimating the total adsorption of a cation because it will not give the exchange capacity but exchange as well as adsorption of the ion by the resin. Though they have claimed (*loc. cit.*) that there is no adsorption, many workers have proved that adsorption does take place. It may be possible that their resin does not adsorb. Hence we have found the exchange capacity of an ion by simply estimating the acid liberated.

EXPERIMENTAL

Resins. The mineral coal (−50, +100 mesh) was mixed with 200 c.c. of oleum sulphuric acid in a beaker and allowed to get sulphonated for 24 hours. The mixture was cooled to prevent the oxidation of the coal. The sulphonated coal was washed repeatedly with distilled water till free of acid. The other resin (anion exchange) used was amberlite IRA 410 (Rohm Haas & Co.) One gram of the resin was shaken for one hour with 100 c.c. of the solution of the electrolyte whose ion had to be exchanged. After one hour 20ml. of the solution was taken out and its acidity determined by titrating with NaOH. The results are as follows:—

TABLE I. Exchange of cations on resin permutit 'S' (sulphonated coal.)

S. No.	Resin (1 gm)	Milli-moles added	*Milimoles of salt exchanged*			*Parachor of cation.*		
			NaCl	KCl	NH_4Cl	$Na^{\cdot}$	$K^{\cdot}$	$NH_4^{\cdot}$
1	Permutit 's'	20.0	0.5893	0.7835	2.146	25.0	54.0	66.5
2	"	15.0	0.5365	0.7155	1.302	"	"	"
3	"	10.0	0.5328	0.5641	1.040	"	"	"
4	"	6.0	0.5204	0.5404	0.8292	"	"	"
5	"	5.2	0.4960	0.5487	0.8130	"	"	"
6	"	2.6	0.4228	0.5447	0.6952	"	"	"
7	"	1.2	0.3699	0.4512	0.5448	"	"	"
8	"	1.0	0.2845	0.3781	0.5365	"	"	"

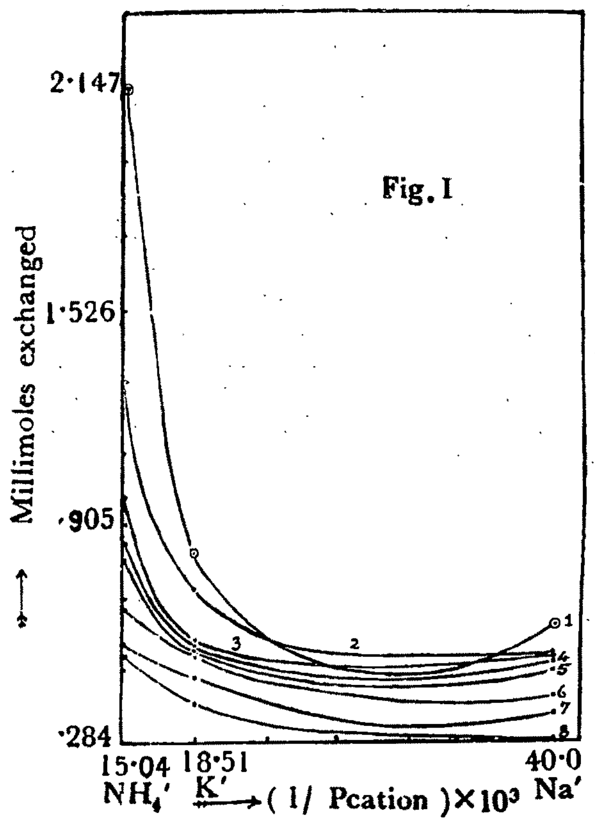

Fig. I

TABLE II. Exchange of anions of resin amberlite IRA 410.

S. No.	Resin (1 gm.)	Milli-moles added	*Millimoles of salt exchanged*					*Parachor of anions*				
			KCl	KBr	KI	$KN0_3$	K_2SO_4	Cl′	Br′	I′	NO_3′	SO_4″
1	Amberlite. IRA 410.	5.0	0.4174	0.517	0.5536,	0.6042	—	54.0	69.94	83.75	86.75	179.8
2	”	0.562	0.2741	0.2803	0.2865	0.2865	0.38	”	”	”	”	”

DISCUSSION

Jenny (5) has shown that the hydrogen ion is more strongly held by a zeolite than any of the other univalent ions, the series from chlorides being $H^{\cdot}$, $Cs,^{\cdot}$ $Rb,^{\cdot}$ $MH_4,^{\cdot}$ $K^{\cdot}$ $Na^{\cdot}$ $Li^{\cdot}$ The hydrogen ion under the same conditions shows a comparatively feeble affinity for organic exchangers containing sulphonic groups the series being $Li,^{\cdot}$ $H,^{\cdot}$ $NH_4,^{\cdot}$ $Rb,^{\cdot}$ $Cs.^{\cdot}$ The low affinity indicates that it is the hydrated volume of the ion which is the determining factor and the resin can be regarded as largely ionised, though not dissociated. Hence it was thought that the exchange affinity should be inversely proportional to hydrated ionic volumes of the ions. The value of the hydrated ionic volume was taken from the

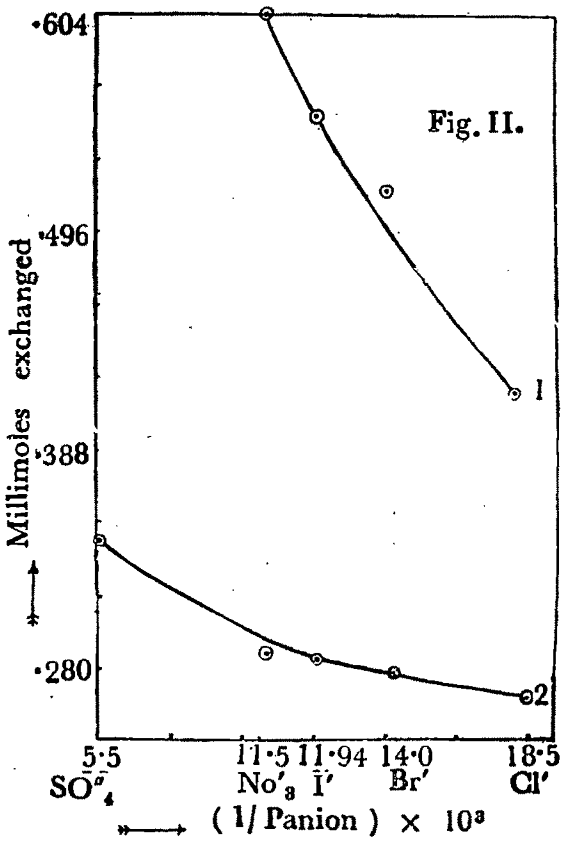

Fig. II.

parachor of the ions, which is measure of ionic volume as determined by Bhagwat, Shukla and Gupta (1). When inverse of the ionic volumes was plotted against the equilibrium exchange of the respective ions (Fig. I and II), the curves are identical with the curves of affinity when plotted against concentration (4, 7). Thus we see that the exchange affinities can be predicted from the ionic parachor or more generally by the hydrated ionic volume (when surface tension is unity.)

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REACTIONS OF IODINE

V. Reaction of Iodine with Pyruvic acid and Levulinic acid

By V. M. Bhale, W. V. Bhagwat and S. L. Bafna, *Dept. of Chemistry, Holkar College, Indore.*

The reaction of bromine with pyruvic acid and levulinic acid was studied kinetically by Hughes and Watson (1) at 25°C. The reaction of bromine with pyruvic acid was fast; but with levulinic acid it was very slow and was accelerated by mineral acids. The rate of the reaction of the acids with bromine was independent of the concentration of bromine; that is, the order with respect to bromine was zero. They concluded that the reaction mechanism involves first enolisation of the acid and then the reaction of the enol form with bromine, the first being the rate controlling, the second being very fast. (2).

We have studied the reaction of aqueous iodine (without potassium iodide) with pyruvic acid (Merck) and levulinic acid (Merck). The experimental procedure followed were similar to those described before (3).

The reaction of pyruvic acid with aqueous iodine (M/1000) at room temperature (~30°C) was very fast. This is consistent with the work of Hughes and Watson (1), since as the concentration of the halogen (here iodine) was very low (due to very low solubility of iodine in water) and the temperature was also higher (~30°C instead of 25°C) and when to this reaction mixture potassium iodide was added, the iodine appeared again. When to the pyruvic acid solution, potassium iodide was first added and then aqueous iodine was added, no detectable reaction took place (for about 24 hours). The reaction rate was measurable at 0 C, for dilute solution (M/400) by following the resistance (R) of the reaction mixture (3), and it was found that when 1/R was plotted against time the plot was initially linear, indicating that the order with respect to iodine is zero, but later the slope of the plot gradually decreased as time increased, presumably due to retardation by I^-ions produced.

The above observations suggest that the reaction between pyruvic acid and aqueous iodine may be the equilibrium reaction cf. 3

$$CH_3.CO.COOH + I_2 \rightleftharpoons CH_2I.CO.COOH + H^+ + I^-$$

the mechanism of the forward reaction being similar to the one given for that of bromine. (1).

The reaction of aqueous iodine (M/1000) with levulinic acid (M/10) was very slow at room temperature (~30°C) requiring several hours for completion and then, when to the reaction mixture potassium iodide was added, the iodine appeared again. The reaction between aqueous iodine and levulinic acid was accelerated by hydrochloric acid. An attempt was made to follow the reaction rate at 30.1°C as follows; but it could not be successful. 50 cc of hydrochloric acid (N/2) and 50 cc. of levulinic acid (M/8) were mixed and kept in the thermostat in a black painted stoppered bottle. Then 100 cc. of aqueous iodine, brought to the thermostat temperature were added and 20 cc. samples were withdrawn added to excess of standard thiosulphate solution and back titrated with aqueous iodine using freshly prepared starch as indicator. However, even when the reaction was over (seen visually), the titre value indicated that no appreciable reaction had taken place (3).

Hughes and Watson (1) have used the titration method for studying the reaction with bromine, but it appears to be inapplicable here, under the conditions used. It is not very clear why it should be so, it may be that here also the reaction between levulinic acid, (LH) and aqueous iodine may be an equilibrium

$$LH + I_2 \rightleftharpoons LI + H^+ + I^-$$

which is shifted almost completely to right giving practically complete reaction but addition of I^-ions shifts it to the left, the mechanism of the forward reaction should be similar to that given for that of bromine (1).

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THE REACTION BETWEEN MALONIC ACID & BROMINE

By S. L. Bafna, V. M. Bhale and W. V. Bhagwat, *Department of Chemistry, Holkar College, Indore.*

The hydrogen atoms of the methylene group in malonic acid are known to be exchangeable with halogens (1) or deuterium (2). Meyer (3), from the study of the reaction between malonic acid and bromine, concluded that the reaction rate was independent of the concentration of the latter and proportional to the concentration of former, and suggested that the measurable step consisted in the slow change from the keto to the enol form of the acid, which reacted with the halogen almost instantaneously.

West (4) reinvestigated the reaction at 0°C in aqueous solution colorimetrically in a modified form of tintometer. He concluded that the bromination of malonic acid to mono-bromo-malonic acid was slower than the bromination of mono-bromo malonic acid to di-bromo malonic acid while the formation of mono-bromo malonic acid is controlled by the enolisation of the keto form, in the bromination of mono-bromo malonic acid, rapid enolisation is followed by a measurable reaction with bromine, the reaction rate thus being of the second order.

In a previous publication, (6) Bafna, Govindan and Bhagwat have studied the reaction between malonic acid and aqueous iodine (without potassium iodide) using a conductivity method and have concluded that the order of the reaction with respect to iodine is zero, and not two as mentioned by Kappana and Talaty (7); the reaction is accelerated by hydrochloric acid and that the reaction mechanism should involve a prototropic change.

We have now studied the reaction between malonic acid and bromine (without potassium bromide) using similar method and some of the results are briefly given here. B.D.H. malonic acid, potassium bromide and potassium iodide were used; other chemicals used were A. R.

Preliminary experiments indicated that the reaction between malonic acid and aqueous bromine, (the concentration of bromine was always much less than that of malonic acid) at room temperature (~ 30 c) was negligible in presence of potassium bromide. But when the concentration of bromine ions was low (absence of potassium bromide) and the concentration of bromide was also low, the reaction was very fast. When, to this reaction mixture, after the completion of the reaction, potassium bromide was added, the bromine was liberated back. However when the concentration of malonic acid was very low (M/2,000) the addition of potassium bromide did not liberate bromine, but bromine was liberated back on the addition of hydrochloric or sulphuric acid to the reaction mixture. This indicated that the reaction at very low concentration of malonic acid is between malonate ion and bromine (6). The reaction between malonic acid and bromine was accelerated by hydrochloric acid. These results are similar to those for the reaction between malonic acid and iodine (and the overall reaction can be written down as $CH_2 (COOH)_2 + Br_2 \rightleftharpoons CH\ Br (COOH)_2 + H^+ + Br^-$ (1).

It was shown in the previous paper (6) that, for the reaction between malonic acid and aqueous iodine, when malonic acid is present in sufficient excess, the decrease in the electrical resistance of the reaction mixture provides a measure of the reaction rate; when the reaction is fast and the measured change in the resistance is small, then to a first approximation the resistance of the reaction mixture should be proportional to time for the validity of zero-order law. (In figure one, of the previous paper (6) the word 'Conductivity' was incorrectly printed, the correct word is 'Resistance'). This was shown to be so previously (6). However the more correct procedure to test the validity of the zero-order law should be to plot the conductivity or the reciprocal of the resistance, (R), of the reaction mixture against time (t) and this should be a linear plot. In table one the values of R and 1/R are given as measured at different times and in Figure 1. the plot of 1/R against time (seconds) is given.

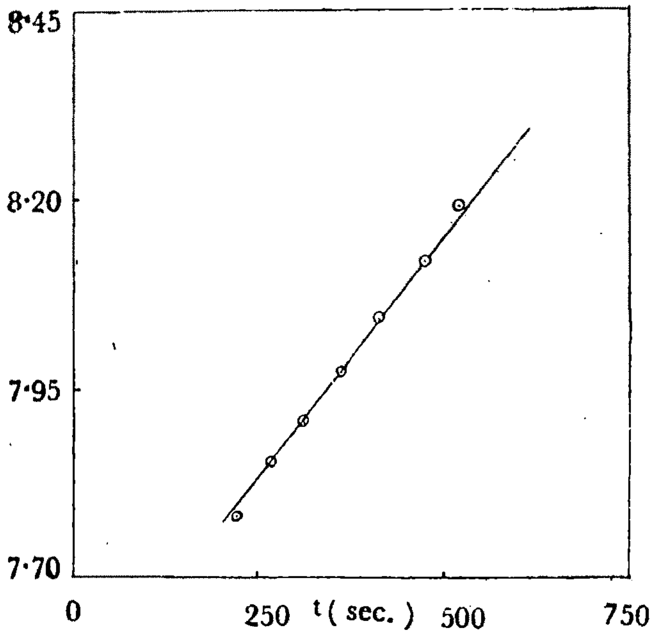
TABLE I.

The Reaction between malonic acid and Aqueous bromine 10^3 [Malonic acid], 2.500 M; 10^4 [Aq. bromine], 2.243 M; temp. 0°c.

t (Sec.)	R (Ohms.)	$10^4/R$ (mhos.)
225	1285	7.780
273	1273	7.855
315	1265	7.905
367	1255	7.970
415	1244	8.040
480	1232	8.120
525	1221	8.190
∞	1197	—

Fig. 1. The reciprocal of resistance of malonic acid-bromino reaction mixture vs. reaction time.

The linear plot supports the conclusion that the order with respect to bromine is zero and that the reaction (1) involves enotisation of the $-CH_2-\overset{|}{C}=O$ group into $-CH=\overset{|}{C}-OH$ group, the subsequent reaction of the enol form with iodine being fast, cf. 5. Further work is in progress.



Relation between malonic acid and bromine.

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THE CONDENSATION OF ALDEHYDES WITH β-KETO-ESTERS IN THE PRESENCE OF ORGANIC BASES

PART II.—OF SALICYLALDEHYDE AND NINE OF ITS DERIVATIVES WITH ETHYLBENZOYLACETATE*

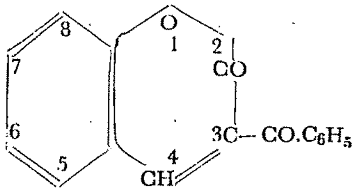
By MISS RAJANI K. PANDYA and KANTILAL C. PANDYA

ABSTRACT

This paper treats of the condensations of salicylaldehyde and of its nine derivatives as in Part I, (8) with ethylbenzoylacetate, in the presence of the three bases (piperidine, pyridine and 2:6-lutidine). The reactivity of the bases is in the same order, piperidine> lutidine> pyridine. The yields are slightly greater than the corresponding yields with ethylacetoacetate (part I), which used to give resin with longer time. As before, the reaction is quickest with the two iodo-derivatives. Halogen substitutions increase the yields and the reaction-velocity as Cl>Br and monohalides> dihalides. Longer time could be given in these reactions without resinification. A definite retardation is noticed with the nitro group substitutions and also in the case of β-resorcylaldehyde in the presence of pyridine and lutidine.

Knoevenagel's reaction between an aldehyde and ethylacetoacetate in the presence of an organic base as a catalyst, is here extended to another β-keto-ester, ethylbenzoylacetate. Salicylaldehyde and its nine derivatives, as in part I (8), give here the corresponding 3-benzoylcoumarins. Our object in studying these condensations is to prepare new coumarin derivatives as well as to compare the effects in these condensations of the aliphatic acetyl group and the aromatic benzoyl group, and also to see the effects of various groups, like Cl, Br, I, NO_2, etc., on the condensations. These condensations are carried out in the presence of the same three organic bases, piperidine, pyridine and 2 : 6-lutidine.

Knoevenagel and Arnot (1904) (4) had obtained 3-benzoyl-coumarin, by condensing salicylaldehyde with ethylbenzoylacetate in the presence of a small amount of piperidine. In this paper, salicylaldehyde and its nine derivatives are condensed in the presence respectively of, alcoholic piperidine, pyridine and 2:6-lutidine. The substituted salicylaldehydes here used are, as before, 5-chloro-, 3:5-dichloro-, 5-bromo-, 3:5-dibromo-, 5-iodo-, 3:5-diiodo-, 3-nitro-, 5-nitro- and 4-hydroxy-(β-resorcyl-aldehyde) salicylaldehydes, and the respective products



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*All this work was done in the Organic Chemical Laboratory of the Institute of Science, Bombay. Our thanks are due to Prof. Jadhav and the Director, Dr. Bharucha for the kind permission.

of the condensations are 6-chloro-, 6:8-dichloro-, 6-bromo-, 6:8-dibromo-, 6-iodo-, 6:8-diiodo-, 8-nitro-, 6-nitro- and 7-hydroxy- 3-benzoyl- coumarins. None of these are so far known in the literature, and they are thus prepared here for the first time and all of them have been characterized by their respective oximes.

As in part I (8, p. 308), here also,all these aldehydes give only one product on account of coumarin formation. Other aldehydes give two distinct products, the mono-esters and the bis-esters, according to the amount of ethylbenzoylacetate used under the same conditions (1, 2, 9, 11, and our succeeding parts).

The catalytic effectiveness of the three bases used is in the same order as before, piperidine > lutidine > pyridine (8).

The mechanism of this type of reaction is also the same as already discussed in part I (8, p. 305-309), the only difference in the two reactions being the presence of the acetyl group in the one and that of the benzoyl group in its place in the second. The benzoyl group here seems to check the speed of the reaction without diminishing the final yield. The reaction with the benzoyl group goes on more slowly, probably due to steric hindrance (10), but ultimately it often gives better yields. In the case of the acetyl group, resinification follows the reaction and the yields, if kept for a longer time, are often decreased. A study of the tables shows that in the present case yields have often reached the quantitative, as in Tables 1, II, IV, V, VI, and approximate to it as in Tables III and X [Compare the Tables in part I also (8)]. Halogenated salicylaldehydes, particularly 5-chloro-, 5-bromo- and the two iodo-derivatives give very good yields, while the remaining salicylaldehydes give less.

Experimental

The general procedure of the condensation was the same as given in part I (ibid). The aldehyde and the ester (1:1 or 1:2 mols) were mixed and dissolved in the minimum quantity of absolute alcohol; piperidine solution (0. I mol) in absolute alcohol (3:8 by volume) was then added, sometimes in two instalments, allowing the mixture to stand at room temperature, or at, -5° for some hours after each addition (3). With pyridine and 2:6-lutidine the procedure was to mix the aldehyde and the ester in the same proportions and then to add the base (6 or 3 mols). The contents were then heated on a water-bath from 5 to 10 hours or much longer in some cases.

When the reaction was complete the mixture was treated with dilute acetic or very dilute hydrochloric acid, and filtered. The solid product was then washed with very dilute alcohol and dried. It was recrystallized from hot absolute alcohol or glacial acetic acid.

The first eight substituted salicylaldehydes were prepared (by R. K. P.) according to the methods given in part I (8, p. 310-13). The last β-resorcylaldeyhde was prepared from β-resorcinol by Gatterman's method, by R. M. Naik in the Institute of Science to whom our thanks are due for the supply.

The oximes of all the benzoylcoumarins were prepared by the method given by Linch (7) for 6-bromo-3-acetylcoumarin, using glacial acetic acid as the solvent and, in some cases, refluxing the mixture for 4-6 hours on a low flame to obtain the pure oxime.

In all the tables given below the last column shows the maximum yields of the corresponding product with ethylacetoacetate in part I (8), so as to give a comparative idea of the yields from the two keto-esters.

All the estimations given in this paper were done by micro-analytical methods. All tne estimations of carbon, hydrogen and nitrogen (except those of the products from resorcylaldehyde) were made at the Bombay University Department of Chemical Technology by Dr. Gore and coworkers. The estimations of the resorcylaldehyde-products were done by R. A. Bhobe in the Institute of Science. Our thanks are due to all of them. The halogen estimations were done at the Institute of Science by one of us (R. K. P.).

Condensation of Salicylaldehyde:—Knoevenagel's experiment (4) was repeated to obtain an authentic specimen of the 3-benzoylcoumarin as well as to work out the percentage yield (which had not been given there). Other variations that were tried were (as in part I, 8) the use of absolute alcohol as a solvent with piperidine and of two more bases, pyridine and 2:6 -lutidine, under different conditions. In all cases the same product, 3-benzoylcoumarin was obtained, in white shining needles, melting at 130° after recrystallization from absolute alcohol (Knoevenagel and Arnot (4) give the same m. p.). It was soluble in absolute alcohol, acetone, ether and glacial acetic acid; insoluble in water, chloroform and carbon tetrachloride.

Table I below gives the yields of 3-benzoylcoumarin with each of the organic bases.

TABLE I

No.	Base	Molar proportions	Temp.	Time	% Yield	Maximum % yield of the acetyl compound
1	Piperidine	1:1:0.2	30°	6 hours	68	
2	" solution	1:1:0.1	30°	10 mins.	80	
3	" "	1:2:0.1	30°	30 "	100	100
4	Pyridine	1:1:6	Waterbath	24 hours	42	
5	"	1:2:6	"	24 "	48	38
6	Lutidine	1:1:3	"	14 "	58	
7	"	1:2:3	"	14 "	62	58

It gave an oxime melting at 149° (dec.) (Knoevenagel and Arnot (4) give 148°—50°).

Condensation of 5-*Chlorosalicylaldehyde*—5-Chlorosalicylaldehyde (8, p. 310) gave 6-chloro-3-benzoyl-coumarin, in very pale yellow needles after recrystallisation from hot absolute alcohol, and melting at 184°. It was soluble in hot glacial acetic acid, hot absolute alcohol and acetone; insoluble in cold alcohol, cold acetic acid, benzene, ether and ligroin. (Found : Cl=12.18%, monochlorobenzoylcoumarin, $C_{16}H_9O_3Cl$, requires 12.47%).

Table II gives the yields of 6-chloro-3-benzoylcoumarin.

TABLE II

No.	Base	Molar proportions	Temp.	Time	% Yields	Maximum % yields of the acetyl Compound
1	Piperidine solution	1:1:0.1	26°	15 mins.	92	
2	" "	1:2:0.1	26°	10 "	100	100
3	Pyridine	1:1:3	Waterbath	6 hours	56	53
4	"	1:2:3	"	6 "	50	
5	Lutidine	1:1:3	"	6 "	86	80
6	"	1:2:3	"	6 "	62	

It gave an oxime melting at 202° (dec). (Found : Cl 12.02%, the oxime, $C_{16}H_{10}O_3NCl$, requires 11.83%).

Condensation of 3:5-*Dichlorosalicylaldehyde*—This aldehyde (8, p. 311) gave 6:8-dichloro-3-benzoylcoumarin, which when recrystallized (absolute alcohol) came out in pale yellow needles melting at 154°. It was soluble in alcohol, acetone, hot acetic acid and ether; insoluble in water, cold alcohol, cold acetic acid, chloroform and carbon tetrachloride. (Found : Cl=22.28%, dichlorobenzoylcoumarin, $C_{15}H_8O_3Cl_2$, requires 22.26%).

Table III gives the yields of 6:8-dichloro-3-benzoylcoumarin.

TABLE III

No.	Base	Molar proportions	Temp.	Time	% Yields	Maximum % yield of the acetyl compound
1	Piperidine solution	1:1:0.1	26°	30 mins.	92	
2	" "	1:2:0.1	28°	20 "	96	88
3	Pyridine	1:1:3	Waterbath	6 hours	50	48
4	"	1:2:3	"	6 "	47	
5	Lutidine	1:1:3	"	6 "	75	71
6	"	1:2:3	"	6 "	60	

It gave an oxime melting at 178° (dec.), (Found : Cl=21.12 %, the oxime, $C_{16}H_{9}0_{3}NCl_{2}$, requires 21.26 %).

Condensation of 5-Bromosalicylaldehyde—5-Bromosalicylaldehyde (8,p.311) gave 6-bromo-3-benzoylcoumarin melting at 175°, after recrystallization (absolute alcohol), in tiny white needles. It was soluble in alcohol, acetone, acetic acid and ether; insoluble in water, ligroin, carbon tetrachloride and chloroform. (Found: Br=24.22%, monobromobenzoylcoumarin, $C_{16}H_{9}0_{3}Br$, requires 24.32 %).

Table IV gives the yields of 6-bromo-3-benzoylcoumarin.

TABLE IV

No.	Base	Molar proportions	Temp.	Time	% Yield	Maximum % yield of the acetyl compound
1	Piperidine solution	1:1:0.1	-5°	75 mins.	90	
2	" "	1:1:0.1	28°	20 "	96	
3	" "	1:2:0.1	-5°	60 "	91	
4	" "	1:2:0.1	28°	10 "	100	93
5	Pyridine	1:1:3	Waterbath	6 hours	48	6
9	"	1:2:3	"	6 "	42	
7	Lutidine	1:1:3	"	6 "	62	58
8	"	1:2:3	"	6 "	58	

It gave an oxime melting at 185° (dec.). (Found : Br=23.10%, the oxime, $C_{16}H_{10}0_{3}NBr$, requires 23.26%).

Condensation of 3:5-Dibromosalicylaldehyde—3:5-Dibromosalicylaldehyde (8, p. 312) gave 6:8-dibromo-3-benzoylcoumarin, in white needles, melting at 196° after recrystallization (absolute alcohol). It was soluble in alcohol, acetone, acetic acid and ether; insoluble in water, ligroin, carbon tetrachloride and chloroform. (Found : Br 39.18%, dibromobenzoylcoumarin, $C_{16}H_{8}0_{3}Br_{2}$, requires 39.21%).

Table V gives the yield of 6:8-dibromo-3-benzoylcoumarin.

TABLE V

No.	Base	Molar proportions	Temp.	Time	% yields	Maximum % yield of the acetyl compound
1	Piperidine solution	1:1:0.1	-5°	6 hours	84	
2	" "	1:1:0.1	28°	3 "	98	

No.	Base	Molar proportions	Temp.	Time	% yield	Maximum %yield of the acetyl compound
3	Piperidine solution	1:2:0.1	-5^0	6 ”	90	
4	” ”	1:2:0.1	28^0	1,5 ”	100	100
5	Pyridine	1:1:3	Waterbath	6 ”	52	50
6	”	1:2:3	”	6 ”	48	
7	Lutidine	1:1:3	”	6 ”	56	52
8	”	1:2:3	”	6 ”	50	

It gave an oxime which melted at 206° (dec.). (Found : Br 37.90%, the oxime, $C_{16}H_90_3NBr_2$, requires 37.83%).

Condensation of 5-*Iodosalicylaldehyde*—5-Iodosalicylaldehyde (8, p. 312) gave 6-iodo-3-benzoylcoumarin, in deep yellow needles, which melted at 226° with decomposition, after recrystallization (glacial acetic acid). It was soluble in acetic acid and acetone; sparingly so in ether and alcohol; insoluble in water, ligroin, carbon tetrachloride and chloroform. (Found : I=33.30%, monoiodobenzoylcoumarin, $C_{16}H_90_3I$, requires 33.55%).

Table VI gives the yields of 6-iodo-3-benzoylcoumarin.

TABLE VI

No.	Base	Molar proportions	Temp.	Time	% yields	Maximum % yield of the acetyl compound
1	Piperidine solution	1:1:0.1	30^0	Immediate solidification	99	
2	” ”	1:2:0.1	30^0	”	100	98
3	Pyridine	1:1:3	Waterbath	2.5 hours	48	
4	”	1:1:3	75^0-80^0	2.5 ”	54	46
5	Lutidine	1:1:3	Water bath	1.5 ”	56	
6	”	1:1:3	75^0-80^0	1.5 ”	68	56

It gave an oxime which melted at 228° (dec.), (Found I=32.15%, the oxime, $C_{16}H_{10}O_3NI$, requires 32.25%).

Condensation of 3:5-*Diiodosalicylaldehyde*—3:5-Diiodosalicylaldehyde (8, p. 312) gave 6:8-diiodo-3-benzoylcoumarin in dirty yellow needles, melting at 238° with decomposition after recrystallization (glacial acetic acid). It was soluble in acetone, acetic acid; sparingly so in alcohol and ether; and was insoluble in water, ligroin, carbon tetrachloride and chloroform (Found : I =50.60%, diiodobenzoylcoumarin, $C_{16}H_80_3I_2$, requires 50.59%).

Table VII gives the yields of 6:8-diiodo-3-benzoylcoumarin.

TABLE VII

No.	Base	Molar proportions	Temp.	Time	% yields	Maximum % yields of the acetyl compound
1	Piperidine solution	1:1:0.1	30°	5 mins.	96	
2	" "	1:2:0.1	30°	5 "	98	86
3	Pyridine	1:1:3	Waterbath	2·5 hours	42	
4	"	1:1:3	75°-80°	2.5 "	50	44
5	Lutidine	1:1:3	Waterbath	1.5 "	54	
6	"	1:1:3	75°-80°	1.5 "	62	50

It gave an oxime melting at 248° (dec.). (Found : I=49.32 %, the oxime, $C_{16}H_9O_3NI_2$, requires 49.12%).

Condensation of 3-Nitrosalicylaldehyde:—3-Nitro-salicylaldehyde (8, p.313) gave 8-nitro-3-benzoyl-coumarin in long and thin white needles, melting at 162° after recrystallization (absolute alcohol). It was soluble in alcohol, acetone, ether and acetic acid; insoluble in water, carbon tetra-chloride, chloroform and ligroin. (Found : N 4.8 % mononitro-benzoylcoumarin, $C_{16}H_9O_5N$, requires 4.74 %).

Table VIII gives the yields of 8-nitro-3-benzoylcoumarin.

TABLE VIII

No.	Base	Molar proportions	Temp.	Time	% yields	Maximum % yield of the acetyl compound
1	Piperidine solution	1:1:0.1	–5°	16 hours	74	
2	" "	1:1:0.1	30°	0.5 hour	80	
3	" "	1:2:0.1	30°	1 "	82	60
4	Pyridine	1:1:6	Waterbath	10 hours	40	30
5	Lutidine	1:1:3	"	10 "	45	42

It gave an oxime melting at 176° (dec.). (Found : N=9.33 %, the oxime, $C_{16}H_{10}O_5N_2$, requires 9.03 %).

Condensation of 5-Nitrosalicylaldehyde:—5-Nitrosalicylaldehyde (8, p. 313) gave 6-nitro-3-benzoyl-coumarin, in stout yellow needles which melted at 192° after recrystallization (absolute alcohol). It was soluble in alcohol, acetone, ether and acetic acid; insoluble in water, ligroin, carbon tetrachloride and chloroform. (Found : N=4.6 %. mononitro-benzoylcoumarin $C_{16}H_9O_5N$, requires 4. 74%).

Table IX gives the yields of 6-nitro-3-benzoylcoumarin.

TABLE IX

No.	Base	Molar proportions	Temp.	Time	% yields	Maximum % yield of the acetyl compound
1	Piperidine solution	1:1:0.1	-5^0	16 hours	80	
2	" "	1:1:0.1	30^0	0.5 hour	86	
3	" "	1:2:0.1	30^0	1 "	93	68
4	Pyridine	1:1:6	Waterbath	10 hours	44	38
5	Lutidine	1:1:3	"	10 "	54	46

It gave an oxime melting at 198° (dec.). (Found : N=9.14 %, the oxime, $C_{16}H_{10}O_5N_2$, requires 9.03 %).

Condensation of β-Resorcylaldehyde:—β-Resorcylaldehyde gave 7-hydroxy-3-benzoylcoumarin (or 3-benzoylumbelliferone), in tiny flesh coloured needles. It melted at 237° after recrystallization (glacial acetic acid). It was soluble in acetone, ether and glacial acetic acid; insoluble in water, benzene, cold alcohol (sparingly soluble in hot), carbon tetrachloride and chloroform. (Found: C=72.8%, H, 3.60%, monohydroxybenzoylcoumarin, $C_{16}H_{10}O_4$, requires 72.2 % and 3.75% respectively. Molecular weight by Rast's method gave 270.20, $C_{16}H_{10}O_4$, requires 266).

Table X gives the yields of 7-hydroxy-3-benzoylcoumarin.

TABLE X

No.	Base	Molar proportions	Temp.	Time	% Yields	Maximum % yield of the acetyl compound
1	Piperidine solution	1:1:0.1	-5^0	12 hours	98	78.6
2	" "	1:1:0.1	28^0	24 "	82	
	" "	1:2:0.1	28^0	24 "	86	
4	Pyridine	1:1:3	Waterbath	24 "	20	
5	"	1:1:3	28^0	3 weeks	39	26
6	Lutidine	1:1:3	Waterbath	24 hours	32	
7	"	1:1:3	28^0	3 weeks	56	38

It gave an oxime melting at 264° (dec.) (Found : N 4.76 % the oxime $C_{16}H_{11}O_4N$ requires 4.98 %).

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LAWS OF FAILURE OF SOLID BODIES DUE TO STRESS AND DESIGN FORMULAE

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The failure of a solid body is due to the occurrence of separated surfaces in its grains. From theoretical considerations of two kinds of starting failure, i. e., sliding and tensile, design formulae and laws have been worked out, so that the parts of machines may be designed to satisfy them. Experiments carried out in the material testing laboratories have confirmed the correctness of these laws.

Sliding failure

(a) *Theory.*—Since sliding failure occurs due to the combined effect of the tangential and the normal components of stress, the true shearing strength

$$R_s = S + kN \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots (1)$$

where S and N are thet angential and the normal components of stress, and k is a co-efficient assumed to be constant for a material. The position of a plane along which sliding occurs, and the relation between the true shearing strength and the state of stress at sliding failure, are determined as follows.

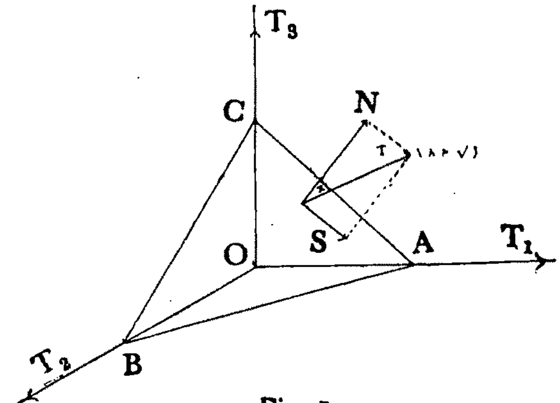

Fig. I

Let T_1, T_2, and T_3 be the principal stresses at a point O in a body, as shown in Fig. 1. T is the stress acting on a plane ABC. α, β, γ and λ, μ, v, are the direction angles of the normal to the plane ABC and those of the stress T, with respect to the directions of the principal stresses, respectively. ψ is the angle between T and the normal. Then,

$$T^2 = T_1^2 \cos^2\alpha + T_2^2 \cos^2\beta + T_3^2 \cos^2\gamma.$$

and, $\cos\lambda = T_1 \cos\alpha / T$; $\cos\mu = T_2 \cos\beta / T$; $\cos v = T_3 \cos\gamma / T$.

$$N = T\cos\psi = T(\cos\alpha . \cos\lambda + \cos\beta . \cos\mu + \cos\gamma . \cos v)$$

$$= T_1 \cos^2\alpha + T_2 \cos^2\beta + T_3 \cos^2\gamma.$$

$$S = T \sin\psi = T(1-\cos^2\psi)^{\frac{1}{2}}$$
$$= [(T_1^2 \cos^2\alpha + T_2^2 \cos^2\beta + T_3^2 \cos^2\gamma) - (T_1\cos^2\alpha + T_2\cos^2\beta + T_3\cos^2\gamma)]^{\frac{1}{2}}$$

From these equations, the position of the plane on which $S+kN$ is a maximum, can be found out. The results are—

(1) In a general state of stress, $S+kN$ becomes a maximum at the two planes the normals of which lie in the plane of the greatest and least principal stresses, say T_1 and T_3 respectively, and make angles of $(\pi/4 - \phi/2)$ with the direction of the greatest principal stress on both sides. This is shown in Fig. 2.

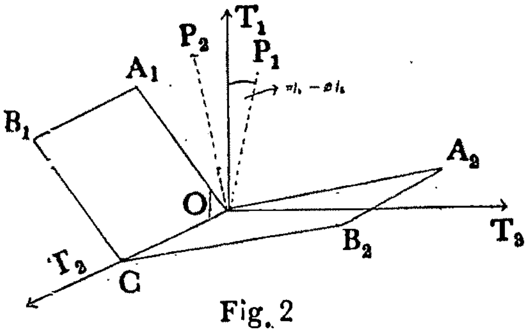

Fig. 2

$$(S + kN)_{\text{max.}} = \frac{1}{2\cos\phi}[T_1 - T_3 + (T_1 + T_3)\sin\phi] \ldots\ldots\ldots\ldots\ldots(2)$$

where $\tan\phi = k$.

(2) In the special case when two of the principal stresses are equal, calling them T_{12}, and the third T_3,

(a) If $T_{12} > T_3$, any straight line on a cone generated by the straight line about the direction of T_3 with the angle of $(\pi/4 + \phi/2)$, is the normal of a plane of maximum $(S+kN)$. This is shown in Fig. 3.

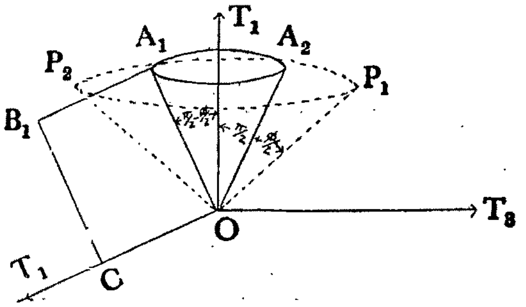

Fig. 3

$$(S + kN)_{\text{max.}} = \frac{1}{2\cos\phi}[T_{12} - T_3 + (T_{12} + T_3)\sin\phi] \ldots \ldots\ldots(3)$$

In Fig. 2, OB_1 and OB_2 are the planes along which sliding failure occurs. OP_1 and OP_2 are normal to OB_1 and OB_2 and lie on the plane of T_1 and T_3 where $T_1 > T_2 > T_3$. In Fig. 3, OB_1 represents one of the planes along which sliding failure occurs, and the cone OA_1A_2 is the envelope of those planes. OP_1 is normal to OB_1 & the cone P_1P_2 is the locus of these normal lines. $T_1 = T_2 > T_3$.

(b) If $T_{12} < T_3$, any straight line on a cone which is generated as above, but with an angle of $(\pi/_4 - \varnothing 2)$ is the normal of a plane of maximum $(S+kN)$, as shown in Fig. 4.

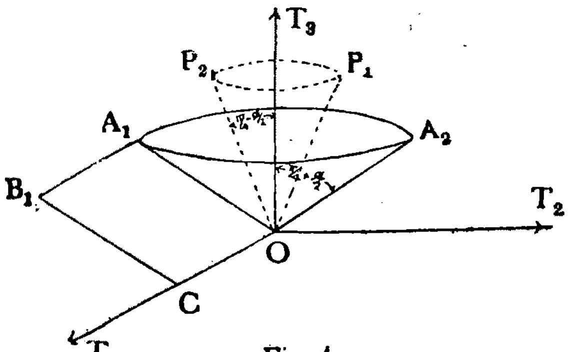

Fig. 4

$$(S + k N)_{max.} = \frac{1}{2\cos\varnothing}[T_3 - T_{12} + (T_3 + T_{12}) \sin\varnothing] \quad \ldots\ldots \ldots\ldots(4)$$

In Fig. 4, OB_1 represents one of the planes along which sliding failure occurs, where $T_1 = T_2 < T_3$ and OA_1A_2 is the envelope of those planes. The cone OP_1P_2 is the locus of the lines normal to such planes as OB_1.

(c) When the three principal stresses are equal to one another, stress is quite normal on any plane, and no sliding can occur.

Some simple cases—

The case of simple tension belongs to (2) (b) above. Sliding occurs along a plane whose normal makes an angle of $(\pi/4 - \varnothing/2)$ with the direction of the

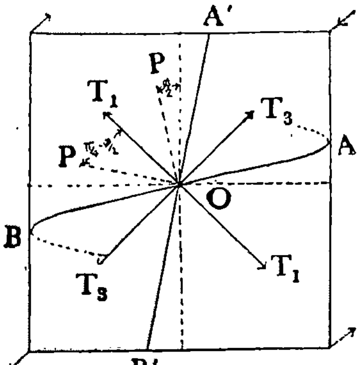

Fig. 5

load. $(S+kN) = \frac{1+\sin\varnothing}{2\cos\varnothing} f_t$ ...(5) where ft is the axial tensile stress at the point of failure. The case of simple compression belongs to (2) (a) above. The normal of a sliding plane makes an angle of $(\pi/4+\varnothing 2)$ with the direction of the load. $(S + kN) = \frac{1-\sin\varnothing}{2\cos\varnothing} f_c$ (6) where f_c is the axial compressive stress at the point of failure. The case of pure torsion of a circular bar belongs to (1). Sliding will occur along a plane tangent to a helical surface which can be generated by a straight line that is radial. The normal at any point of the surface makes an angle of $(\pi/4-\varnothing 2)$ with the direction of the principal stress at that point. This is shown in Fig. 5. $(S+kN)=f_s/\cos\varnothing$.——————(7) where f_s is the maximum shear stress at the point of failure, which is usually the shearing strength of the material.

EXPERIMENTS ON SLIDING FAILURE

Bars of mild steel, wrought iron, brass, and copper were annealed and tested. They were subjected to simple tension and pure torsion, in testing machines.

In a ductile material, the central part of the fracture shows a tensile failure and its external part, a sliding failure. When the load has reached its maximum, there occurs at first, the sliding failure along a conical surface the axis of which is that of the specimen. Then there follows a continuous sliding along continuous conical surfaces as shown in Fig. 6. The envelope of the outer edges of the conical surfaces shows the local contraction. The material along the axis cannot slide along the conical surfaces, but moves along the axis. Consequently, even though the outer part of the specimen recives ultimate sliding failure, a complete failure does not occur, until the resistance of the central part to tensile failure is overcome.

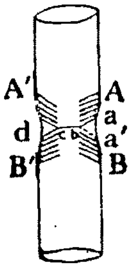

Fig. 6

In pure torsion, the load is maximum at the breaking point. There is no local contraction : and the whole fracture is caused by sliding failure. The shearing stress that produces the ultimate sliding failure was calculated from the load at the breaking point and the cross section at the fracture. Prandtl's formula for the shear stress in pure torsion was used:—

$$f_s = \frac{3M+\Theta.dM/d\Theta}{2\pi r^3} \quad (8)$$

in which f_s=the shear stress at the circumference of a cross-section.

M=the twisting moment applied.

Θ=the angle of twist.

r=the radius of the section.

The quantity $\Theta.dM/d\Theta$ was obtained from the $M-\Theta$ diagram. The angle of fracture was measured by throwing an image of the specimen, magnified by lenses, on a screen, so that it showed the straight part of the fracture. The inclination of the fractured surface of a torsion specimen to its circumferene, was measured by developing the edge of fracture on to a sheet of paper. A certain point on the edge, lies in a straight line which has the direction of the circumference. The angle between the helical part of the fracture and the circumference, is measured.

Experimental results.—According to the theory, f_s/f_t should be equal to $\frac{1+\sin\varnothing}{2}$ at the elastic limits and at the maximum loads; and $\varnothing=\sin^{-1}(2f_s/f_t-1)$. The slided part of the fracture by tension should contain an angle $\pi/4+\varnothing/2$ with the axis. The straight part of the development of the edge of fracture in torsion must make an angle of $\varnothing/2$ with the circumference.

Tables 1, 2, 3, and 4, give the results of experiments with mild steel. wrought iron, brass, and copper. These results confirm the theory. The tables are given at the end.

TENSILE FAILURE

(a) *Theory.*—Tensile failure is, as in the case of sliding failure, affected by the tangential component of stress. The tensile resistance of a material within a solid body, decreases as the tangential component of stress acting on the plane, increases. If R_t is the tensile strength per unit area of a plane where there is no tangential component of stress, tensile separation is likely to occur at a plane where $(N+kS)_{max.}=R_t$. Hence, as before the position of the plane at which tensile failure will occur, and the relation between the principal stresses, and R_t, are as follows—(1) In a general state of stress, $N+kS$ becomes a maximum at two planes, the normals of which lie in the planes of the greatest and the least stresses, say T_1, and T_3., and make angles $\varnothing/2$ with the direction of the greatest principal stress on both sides, as in Fig. 7. $(N+kS)_{max.}$ is $=\frac{1}{2\cos\varnothing}\left[T_1-T_3+(T_1+T_3)\cos\varnothing\right]$...(9), in which $\tan\varnothing=k$.

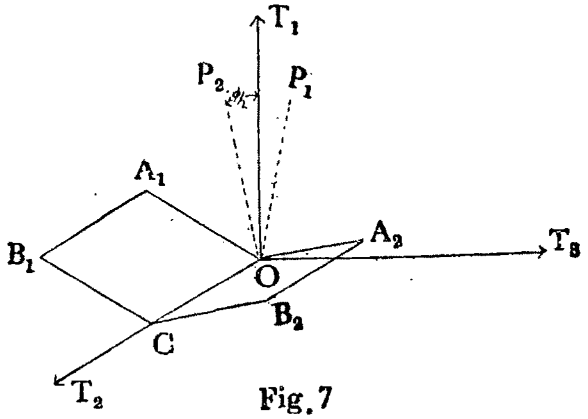

Fig. 7

(2) In the special case when two of the principal stresses are equal, say T_{12}, & the third T_3.

(a) If $T_{12} > T_3$, the normal of a plane of max. N+kS, lies on a cone that is generated by a straight line about T_3 with an angle $\varnothing/2$. (Fig. 8)

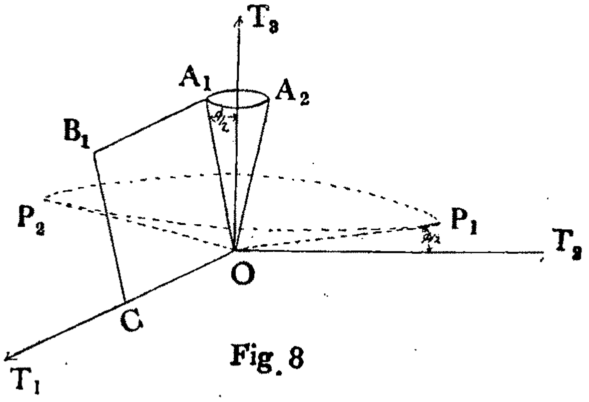

Fig. 8

$$(N+kS)_{max.} = \frac{1}{2\cos\varnothing}\left[T_{12} - T_3 + (T_{12}+T_3)\cos\varnothing\right] \ldots (10)$$

(b) If $T_{12} < T_3$, $(N+kS)_{max.} = \dfrac{1}{2\cos\varnothing}\left[T_3 - T_{12} + (T_3+T_{12})\cos\varnothing\right] \ldots (11)$

This is shown in Fig. 9.

(c) If the three principal stresses are equal to one another, $(N+kS) = T_{1,2,3}$, at any direction. Hence any plane can be the plane of tensile failure, when the stress $= R_t$.

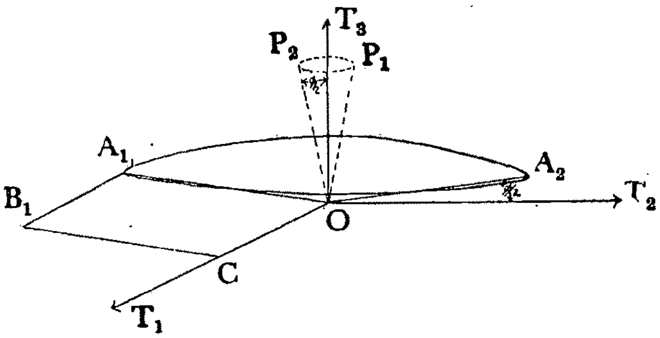

Fig. 9

Some simple cases—In simple compression, tensile failure occurs at a plane the normal of which makes an angle of $\varnothing/2$ with the load.

$$R_t = f_t\,\frac{1+\cos\varnothing}{2\cos\varnothing} \ldots (12).$$

where f_t is the axial tensile stress at failure.

Pure torsion gives tensile failure at a place, tangent to a helical surface generated by a radial straight line and the normal of which at any point makes an angle of $\varnothing/2$ with the directions of the principal stress at that point. There are two such surfaces as in Fig. 10. $R_t=f_s/\cos\varnothing$.——(13) where f_s is the maximum shear stress at the point of failure. The state of stress in simple compression is such that there is no tangential component of stress on any plane, and hence, tensile failure cannot occur.

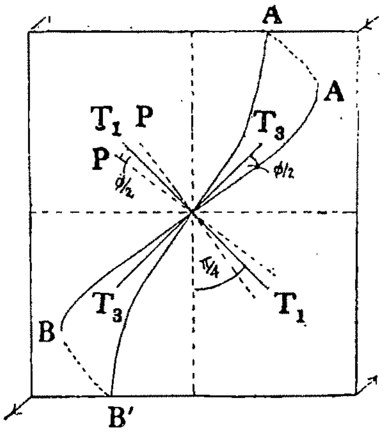

Fig. 10

Experiments on tensile failure.—Since materials that fail by tensile separation are brittle, cast iron was tested. The theory requires that $f_s/f_t=\frac{1+\cos\varnothing}{2}$ and $\varnothing=\cos^{-1}[2(f_s/f_t)-1]$ and the fracture contains an angle $(\pi/2-\varnothing/2)$ with the axis in a tension specimen and the development of the edge of fracture of a torsion specimen, an angle of $(\pi/4-\varnothing/2)$ with the circumference. Table 5 gives the results.

TRUE STRENGTH OF MATERIALS

The theory given above and the experimental evidence point to the existence of two kinds of true strength, namely true shear strength and true tensile strength. In an isotropic body, whether ductile or brittle, the relations between the true strength, elastic, or ultimate, and the principal stresses at failure may be expressed by the equations—

$$R_s=\frac{1}{2\cos\varnothing}[(T_1-T_3+(T_1+T_3)\sin\varnothing]\ldots(14)$$

at sliding failure, and

$$R_t=\frac{1}{2\cos\varnothing}T_1-T_3+(T_1+T_3)\cos\varnothing] \;.\; (15)$$

at tensile failure, in which,

R_s = true shearing strength,
R_t = true tensile strength,
T_1 = greatest principal stress at failure,
T_3 = least principal stress at failure,
$\Theta=20^\circ$.

For a ductile material, T_1 is greater in simple tension than in the case where T_3 is negative, as in pure torsion and in a hollow cylinder subjected to internal fluid pressure. The fact that a piece of ductile material under simple tension starts to fail by sliding, tells us that—$T_1' > T_1$ or, $\frac{2\cos\varnothing}{1+\cos\varnothing}\cdot R_t$, is greater than $\frac{2\cos\varnothing}{1+\cos\varnothing}.R_s.$, where T_1' is the value of the greatest principal stress at an assumed tensile failure under simple tension, T_1 that at an actual sliding failure under a simple tension. In a ductile material therefore,

$R_t > \frac{1+\cos\varnothing}{1+\sin\varnothing}.R_s$ or, 1.45 R_s. or, $R_s < 0\ 69\ R_t$.

For a brittle material, which fails by shearing under simple compression, $R_s = \frac{1-\sin\varnothing}{2\cos\varnothing}\ f_c = 0.35\ f_c$ in which, f_c is the compressive stress at failure. From the fact that a brittle material under simple tension, does not start to fail by sliding, $R_s > \frac{1+\sin\varnothing}{1+\cos\varnothing}.\ R_t$, or, 0.69 R_t or, $R_t < 1.45\ R_s$.

Comparison of strength, elastic or ultimate of an isotropic body under several states of stress

State of stress	ductile material	brittle material
Simple tension	$f_t = \frac{2\cos\varnothing}{1+\sin\varnothing} R_s$ $= 1{\cdot}40\ R_s$	$f_t = \frac{2\cos\varnothing}{1+\cos\varnothing} R_t$ $= 0{\cdot}97\ R_t$
Simple compression	$f_c = \frac{2\cos\varnothing}{1-\sin\varnothing} R_s$ $= 2{\cdot}86\ R_s$	$f_c = \frac{2\cos\varnothing}{1-\sin\varnothing} R_s$ $= 2\ 86\ R_s$
Pure torsion	$f_s = \cos\varnothing\ R_s$ $= 0{\cdot}94\ R_s$	$f_s = \cos\varnothing\ R_t$ $= 0{\cdot}94\ R_t$

Design formulae

Since the resistance produced in a material should not exceed its true shearing or true tensile strength, a structural element should be designed so that it satisfies the following two conditions as regards its working state of stress.

$\frac{1}{2\cos\varnothing}[T_1 - T_3 + (T_1 + T_3)\sin\varnothing]$ should not exceed R_s. and,

$\frac{1}{2\cos\varnothing}[T_1 - T_3 + (T_1 + T_3)\cos\varnothing]$ should not exceed R_t.

where T_1 and T_3 are the greatest and the least principal stresses at any point of the element in its working conditions.

Acknowledgement

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TABLE I (mild steel)

tension

No. of specimen	diameter in inches			Load in pounds			Stress fc in p.s. i.			Angle of fracture
	initial	At max. load	At fracture	At elastic limit	max.	At breaking point	At elastic limit	At max. load	At breaking point	
1	·253	·231	·175	1540	3164	2464	29700	74850	101300	55°
2	·253	·228	·170	1596	3220	2240	31510	78890	98700	54°
							30605	76870	10000	

torsion

No. of Specimen	diameter in inches		M in inch-pounds			Stress f_3 in p.s.i.		Angle of fracture
	initial	At fracture	At elastic limit	At breaking point		At elastic limit	At breaking point	
				M	$\Theta\ {}^{dM}/{}_{d\Theta}$			
1	1·00	1·00	5100	12200	1200	19950	51190	10°
2	1·00	1·00	5200	12250	1300	20250	51700	10°
						20100	51445	

TABLE II (wrought iron)

tension

No. of Specimen	diameter in inches			Load in pounds			Stress ft in p. s. i.			Angle of fracture
	initial	At max. load	At fracture	At elastic limit	Max.	At breaking point	At elastic limit	At max. load	At breaking point	
1	.253	·229	.195	2268	3360	2968	44760	80870	98400	55°
2	.253	·226	.190	2184	3248	2800	43110	98790	98790	55°
Mean							43935	80920	98595	

torsion

No. of Specimen	diam. in inches		M in inch-pounds			Stress f_s in p.s.i.		Angle of fracture $\varnothing/2$
	initial	At fracture	At elastic limit	At breaking point		At elastic limit	At breaking point	
				M	$\Theta \frac{dM}{d\Theta}$			
1	1·00	1·00	8040	14800	2000	31100	59200	·8
2	1·00	1·00	7760	14560	1900	30050	58050	6°
Mean						30575	58625	

TABLE III (brass)

tension

No. of Specimen	diameter in inches			Load in pounds		Stress ft in p. s. i.		Angle of fracture $\pi/4 + \varnothing/2$
	initial	At max load	At fracture	At max.	At breaking point.	At max. load	At breaking point	
1	·253	·220	·188	3024	2940	79560	105900	53°
2	·253	·223	·190	3065	3052	77780	107700	55°
Mean						78670	106800	

torsion

No. of Specimen	diameter in inches		M in inch-lbs. at break		Stress fs in p.s.i	Angle of fracture $\varnothing/2$
	initial	At fracture	M	$\Theta\, dM/d\Theta$	At breaking point	
1	1.00	1.00	12830	2800	52600	10°
2	1.00	1.00	12370	2900	50950	10°
Mean					51775	

TABLE IV (copper)

tension

No. of Specimen	diameter in inches			Load in pounds		Stress ft. in p.s.i.		Angle of fracture $\pi/_4 + \Theta/_2$
	initial	At max. load	At fracture	At max.	At breaking point	At max. load	At breaking point	
1	·253	·207	·148	1540	1294	45540	75430	51°
2	·253	·212	·150	1624	1320	46020	74690	48°
Mean						45780	75060	

torsion

No. of Specimen	diameter in inches		M in inch-lbs at break		Strass f_s in p.s.i.	Angle of fracture $\varnothing/_2$
	initial	At fracture	M	$\Theta \frac{dM}{d\Theta}$	At breaking point	
1	1·00	1·00	8250	1000	32800	7°
2	1·00	1·00	7710	900	30600	8°
Mean					31700	

TABLE V (cast iron)

torsion

No. of Specimen	diameter in inches	Ultimate load in lbs	Ultimate Stress p. s. i.	Angle of fracture $\pi/2 - \varnothing/2$	$\varnothing$
1	·253	863	17130	80°	20°
2	·253	812	16030	80°	
Mean			16580		

torsion

No. of Specimen	diameter in inches	M in inch-pounds	$\Theta \cdot \frac{dM}{d\Theta}$	Stress in p. s. i.	$\pi/4 - \varnothing/2$
1	1·00	3870	1100	16200	35°
2	1·00	3780	1200	15960	35°
Mean				16080	

PRELIMINARY INVESTIGATIONS ON THE DISEASE INTENSITY AND CROP LOSS IN THE SMUT OF *BAJRA PENNISETUM TYPHOIDES* STAPF AND HUBB. CAUSED BY *TOLYPOSPORIUM PENICILLARIAE* BREF.

By S. K. CHAUHAN, *Botany Department, Agra College, Agra.*

INTRODUCTION

The smut of *bajra* (*Pennisetum typhoides* Stapf and Hubb.) caused by *Tolyposporium penicillariae* Bref. is a common and wide-spread disease in U.P. Its mode of infection through the flowers at the time of anthesis, the probable spread and recurrence have been subjects of earlier investigations (1, 2, 3 and 5), but very little is known regarding the disease intensity and crop loss caused by the parasite. Further, no data are available on the micro-climatic factors which profoundly affect disease development. In this paper some preliminary data have been gathered on the disease intensity and crop loss correlation in cultivator's fields, confined to three more or less climatically different localities in western U. P., where *bajra* is an important *kharif* crop. Observations have also been recorded on the prevailing micro-climatic factors (temperature and relative humidity) in the fields at the probable time of infection.

METHODS AND MATERIAL

Observations were carried on during the *kharif* 1953 in Agra District (village: Gopalpura), Mainpuri District (village: Madanpur) and Bareilly District (village: Attarchheni). For estimating the disease intensity and loss of ears from healthy and diseased area-units (2′×2′), selected at random, were harvested from respective fields and brought carefully to the laboratory in separate packets where observations were recorded and statistical calculations made.

DISEASE INTENSITY

The disease intensity was measured by reducing the visual observations of symptoms to a quantitative index. The whole ear with a supposed total score of 100 points was divided into five equal parts transversely, and 20 points were given to each. Again each cylindrical part was divided into four equal sectors length-wise and five points were given to each sector. The scoring of the ear depended on the extent and density of the infected grains. Thus a fully infected ear scores 100 points if all the grains are infected. A healthy ear without any infected grain scores 0.0 points.

Observations on the dry weight of grains from healthy and diseased units, and loss of grains in the diseased units were recorded to correlate the disease intensity and loss in yield.

LOSS ESTIMATES

Chester's individual method (4) for estimating loss has been adopted with the modification that instead of pairs of healthy and diseased individuals, small unit-areas, $(2' \times 2')$ healthy and diseased, covering about 5% of the field area were taken. The unit having even one diseased plant was considered as diseased while in a healthy unit all the plants were disease free. Such a type of sampling was done in all the three localities. The loss has been estimated in gms. from yields in healthy and diseased units as follows:—

Loss in yield (in gms.) $=$ Yh-Yd, where Yh is the yield of healthy unito and Yd the yield of the diseased unit.

In order to determine if loss is significant 't' value $\left(\frac{\text{Loss in yield}}{\text{Standard error}}\right)$ was calculated for each locality and also for combinations of localities. Similarly correlation coefficients (*r* value) between loss in yield and percentage disease intensity were also determined. Regression coefficient (*b* value) indicating the loss in yield for unit increase in the disease intensity was also calculated where ever '*r*' value is significant.

MICRO-CLIMATE

Micro-climatic factors were confined to temperature and relative humidity at the time of anthesis when the infection is likely to occur. Thus the micro-climatic factors could only be studied in relation to infection. Continuous curves for temperature and relative humidity were obtained by placing a thermo-hygrograph within the stand of the crop about 9 inches above the ground. The apparatus was placed for 24 hours in the field of each locality at an interval of two days about the time of anthesis, and three such readings were taken thus giving an idea of the range of temperature and relative humidity for a period covering nine days. As the anthesis in the three localities was found to occur at different times there was no difficulty in recording the observations.

RESULTS

Disease Intensity

TABLE I. Disease intensity in disease units.

Nature of observation	Locality		
	Agra (village: Gopalpura)	Mainpuri (village : Madanpur)	Bareilly (village: Attarchheni)
1. Disease intensity score per unit	71·28 ±9·50	46·00 ±9·80	73·35 ±9·10
2. Average no. of ears per unit (i. e. thickness of stand)	4·75		3·57

Nature of observation	Locality		
	Agra (village: Gopalpura)	Mainpuri (village : Madanpur)	Bareilly (village : Attarchheni)
3. Average disease intensity score per ear (% per unit)	14·73 ±2·9	15·47 ±3·2	21·21 ±3·01
4. *Average disease intensity per ear for the whole field.	7·7 ±1·32	7·9 ±1·40	11·08 ±0·51

*In this calculation the healthy plants of the field are also taken into account, so as to make comparisons possible with certain data concerning the entire field.

Data on the disease intensity score per unit and the thickness of the stand are utilised to give the average disease intensity score per ear (*i.e.* percentage disease intensity) for the disease unit and also for the whole field. The high standard errors in the above observations indicate that the disease intensity is not uniform in the fields. The percentage disease intensity per unit as well as average disease intensity for the whole field are nearly the same for Agra and Mainpuri but lower than those for Bareilly.

Crop Loss

TABLE II. Observations on yield from healthy and diseased units and loss.

Nature of observations.	Locality		
	Agra (village: Gopalpura) (14 units)	Mainpuri (village: Madanpur) (12 units)	Bareilly (village: Attarchheni) (14 units)
1. Mean yield of grain (in gms.) for healthy unit.	83·41 ±5·13	50·517 ±4·900	73·275 ±3·510
2. Mean yield of grain (in gms.) for diseased unit.	70·07 ±4·40	37·037 ±3·500	52·449 ±2·800
3. Mean loss in yield (in gms.) per unit.	13·48* ±3·5	13·33* ±4·1	20·825** ±3·500

*Significant at 5% level; **Significant at 1 % level.

The loss in yield is significant in all the three localities and more so in Bareilly, showing that there is a definite relationship between disease intensity and loss in yield. The loss is almost the same at Agra (Gopalpura) and Mainpuri (Madanpur) while at Bareilly (Attarchheni) it is higher.

Disease Intensity and Crop Loss Relationship

TABLE III. Correlation coefficients ('r' values) and regression coefficients ('b' values) between percentage disease intensity and loss in yield.

Locality	Correlation coefficient ('r' value)	Regression coefficient ('b' value)
1. Agra (village : Gopalpura)	+ 0·291	——
2. Mainpuri (village : Madanpur)	0·440	——
3. Bareilly (village : Attarchheni)	0·613*	0·698

*Significant at 5% level.

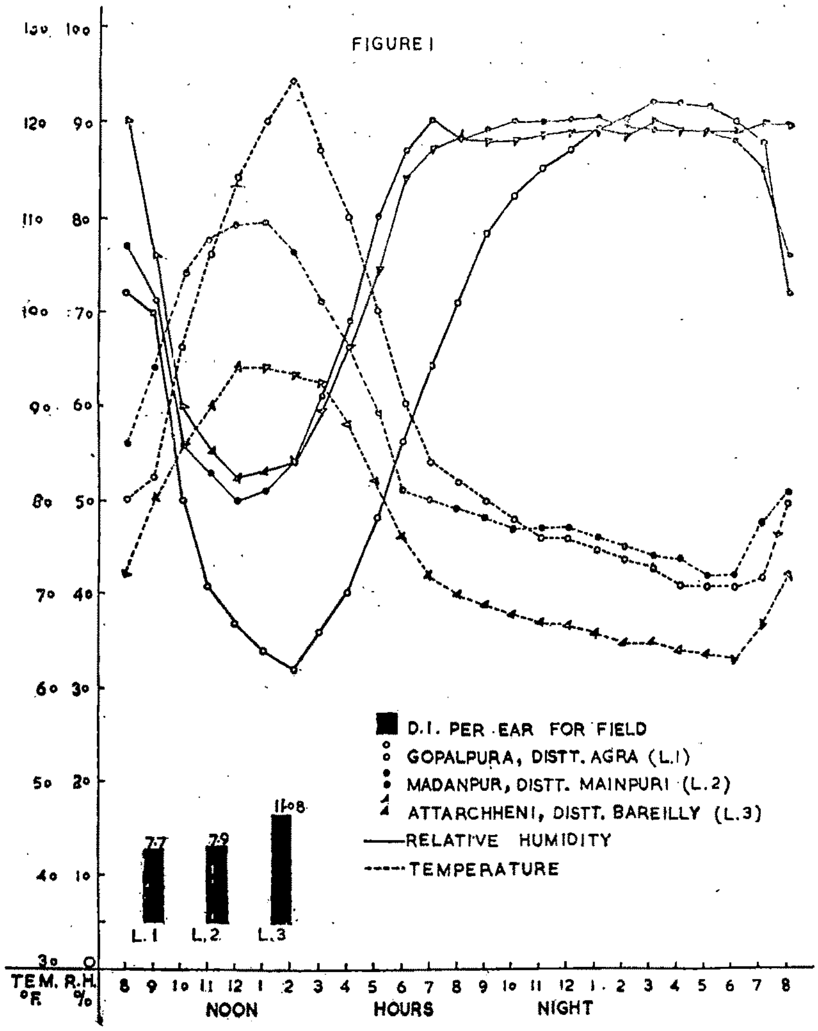
The correlation coefficients are not significant at Agra and Mainpuri but at Bareilly it is significant at 5% level. The lack of correlation can be attributed to larger variations in crops and also in the disease intensity at Agra and Mainpuri although five percent of the field area, to satisfy statistical needs, was taken into account. Thus from the present investigations correlation between crop loss and disease intensity can be indicated only for Bareilly while more extensive observations have to be made in Agra and Mainpuri.

Regression value '*b*' calculated for significant correlation indicates that in Bareilly for each 1% increase in disease intensity loss in yield amounts to 0.698 gms. Calculated on area basis the loss in yield will increase on an average by 84.084 lbs. per acre for 10% increase in the disease intensity in the field under observation in Bareilly.

MICRO-CLIMATE AND DISEASE INTENSITY

The micro-climatic conditions of the stands in the three localities are brought out in fig. 1., where graphs have been drawn with respect to average relative humidity and temperature for a period of nine days (the period of anthesis) and the disease intensity shown by the vertical lines. Although the curves relate to the period of anthesis (time of infection of ears) alone yet there seems to be some direct relationship between disease intensity and the micro-climatic factors. In Bareilly a greater disease intensity (11.08) is associated with a lower range of temperature (68°-95° F) and higher relative humidity (54-92%, 90% for about 12 hours), while at Agra with a temperature range of 76°-122°F and relative humidity 31-90%, (90 % only for 2 hours) the disease intensity is lower (7.7).The relationships at Mainpuri are not clear.

FIGURE I



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EFFECT OF SHALLOW AND DEEP SOWING ON THE INCIDENCE OF ROOT-ROT AND WILT OF *CYAMOPSIS PSORALIOIDES* DC.

By R. S. Singh, M. Sc. (Ag.), *Govt. Agricultural College, Kanpur.*

The incidence of root-diseases of plants is known to be influenced by the soil-moisture (1) which varies according to the depth of the soil. The depth at which the seeds are planted in the soil has an important bearing upon the incidence of pre-emergence loss and seedling-infection. Apart from moisture, the soil-temperature, time taken by the seedlings for emergence and the development of secondary roots in deep sowing may also play some role in influencing the infection, subsequent mortality and recovery. Thus modifications in the method of sowing resulting in reduction of the soil moisture around the seeds, roots and stem base can reduce the mortality of plants due to root disease fungi.

To test the possibility of lowering the incidence of root-rot and wilt of 'guar' (*Cyamopsis psoralioides* D.C.), caused by *Rhizoctonia solani* Kuhn and *Fusarium coeruleum* (Lib.) Sacc. (Singh, 2), through suitable alterations in the depth of sowing some experiments were carried out at Kanpur during 1951-52.

Experimental

The experiments were run in three series. In one series the soil was given no additional dose of inoculum and the seeds were sown broadcast over the pulverised surface of the beds. In the other two series the seeds were sown in furrows behind the particular implements. The soil of these two series was inoculated with cultures of the two fungi in rows separately.

The adjustment of the depth of sowing was accomplished by using different kinds of implements for the sowing operation. Determination of the soil-moisture at the sowing depth was carried out from samples taken at the time of sowing and during the third and fifth week after sowing. It was observed that due to rainy season there was not-much variation in moisture content of the soil at the same depth till the end of August.

The incidence of mortality in the different treatments of each series was recorded at regular intervals for eight weeks after sowing (Tables I-IV). The first series of the experiments was repeated twice during the years 1951 and 1952.

The infection and mortality of the plants of *Cyamopsis* in broadcast sown plots (Tables I and II has been lowest when the seeds are sown at an approximate depth of two centimeters i.e., the depth just covered with a light amount of soil Deeper sowings with higher moisture (and a narrow range of temperature) in the soil cause increased infection and mortality. The mean percentage of mortality in the first treatment differs significantly from the remaining three treatments whose variations in respect of mortality are insignificant and the mortality is statistically identical.

The figures for emergence of seedlings in rows inoculated with *R. solani* can be divided into three classes according to the significance of the differences between treatments. In the first group come the treatments consisting of sowing behind hand rake and harrow (2.5 and 5.0 cms. depth). In these two treatments the emergence has been identical but significantly higher than in other treatments. The second group consists of the treatments in which seeds were sown behind cultivator or ordinary plough cutting approximately 7.8 and 11.5 cms. deep furrows respectively. The emergence is slightly less than in the first group. Lastly, there has been maximum inhibition of emergence when the seeds are planted at the depth of about 14 cms. behind a meston plough. There has been increase in the soil-moisture content as well as in the time taken for emergence with the increase in the sowing depth, and this has given greater opportunity to *R. solani* to cause pre-emergence seedling-rot. The emergence is almost complete within five days when the seeds are sown not deeper than 5.0 cms. In sowings behind a plough the perfect emergence is reached in about nine days.

TABLE 1. Effect of the depth of sowing broadcast on the incidence of mortality in *Cyamopsis psoralioides* during 1951.

Method of adjusting the sowing depth	Approximate resulting depth of sowing (cms.)	Approximate soil moisture on the day at sowing depth (percent)	Percentage of plants killed
Seeds broadcast on surface of the soil and :			
Raked in with hand rake	2·0	13·9	6·7
Harrowed in with spring tine harrow	5·0	20·2	11·9
Mixed into the soil with a cultivator	8·0	24·3	13·2
Ploughed in with an ordinary plough	12·0	29·7	13·0
C.D. at 5%	—	—	1·4
at 1%	—	—	2·0

TABLE II. Effect of the depth of sowing broadcast on the incidence of mortality in *Cyamopsis psoralioides* during 1952.

Method of adjusting the sowing depth	Approximate resulting depth of sowing (cms.)	Approximate soil moisture on the day at sowing depth (percent)	Percentage of plants killed
Seeds broadcast on surface of the soil and :			
Raked in with hand rake	2·7	11·0	5·8
Harrowed in with a spring tine harrow	5·0	19·0	10·3
Mixed into the soil with a cultivator	8·3	21·2	11·4
Ploughed in with an ordinary plough	12·6	25·9	12·7
C. D. at 5%	—	—	0·9
at 1 %	—	—	1·3

TABLE III. Incidence of mortality in *Cyamopsis psoralioides* as affected by the depth of sowing in rows inoculated with cultures of *R. solani*

Method of sowing	Approx. depth of the furrows (cms.)	Approx. soil moisture at the sowing depth (p.c.)	Emergence (p. c.)	Mortality (p.c.)
Seeds sown in furrows cut by :				
Hand Rake	2·5	13·2	85·0	39·3
Harrow	5·0	19·0	83·0	40·0
Cultivator	7·8	24·2	77·0	48·3
Ordinary plough	11·5	27·9	75·0	49·1
Meston plough	14·0	28·4	68·0	49·6
C.D. at 5%	—	—	3·9	1·5
at 1%	—	—	5·6	2·1

TABLE IV. Incidence of mortality in *Cyamopsis psoralioides* as affected by the depth of sowing in rows inoculated with cultures of *F. coeruleum*

Method of sowing	Approximate depth of the furrows (cms.)	Approximate soil moisture at the sowing depth (p. c.)	Emergence (p.c.)	Mortality (p.c.)
Seeds sown in furrows cut by :				
Hand rake	2·5	13·2	99·0	33·8
Harrow	5·0	19·7	100·0	34·4
Cultivator	7·8	24·2	95·0	34·8
Ordinary plough	11·5	27·9	91·0	36·2
Meston plough	14·0	28·4	88·0	38·6
C. D. at 5 %	—	—	5·1	1·1
at 1 %	—	—	7·2	1·5

The plant mortality in the same series varies between 39 and 50 percent. Upto a sowing depth of about five centimeters the mortality is statistically identical and lower than the deeper sowings. In the remaining treatments consisting of the sowing depth from 7.8 to 14.0 cms. the percentage of plants killed is significantly higher than in the first two treatments.

Results from rows inoculated with cultures of *F. coeruleum* (Table IV) indicate that the fungus does not produce any inhibitory effect on the emergence of seedlings and the latter is equally good in all the treatments except when the seeds have been planted behind a plough. Only in this treatment (14 cms. depth) there has been a significant decrease in the percentage of emergence. There is no effect of the different depths of sowing upto 7.0 cms. on the relative incidence of mortality. The differences between mean percentages are insignificant. In the remaining two treatments where the seeds are sown 11.5 and 14.0 cms. deep the differences between mortality figures are very highly significant and higher than those in the first three treatments.

DISCUSSION

During the studies on seedling-rot, root-rot and wilt of *Cyamopsis psoralioides* DC. it has been observed under field conditions that recovery amongst diseased plants is possible through the development of secondary roots. This is more common when the seeds have been planted deep or when soil has somehow accumulated around the base of the stem. Inspite of this fact the total mortality in these experiments has been significantly higher in deep sowings than in shallow sowings.

There is another fact which requires consideration. The mortality in 'guar' is caused by *R. solani* and *F. coeruleum* both attacking the roots in different stages of plant growth. The wilting by the latter fungus occurs even when the roots of *Cyamopsis* have gone deep. Therefore, the moisture and temperature conditions of the soil at the sowing depth have no relationship with the infection of roots in later stages of the plant growth.

The major part of the total mortality in *Cyamopsis* is due to seedling-rot and root-rot of young plants caused by *R. solani*. Tender immature parts of the host are more easily attacked than the hard mature parts. It has been observed during these experiments that the differences in the mortality in various treatments were pronounced mostly during seedling stage rather than when the plant were grown up. This has indicated that there has been no effect of depth of sowing on the mortality of grown up plants.

Therefore, the only explanation for the reduced mortality in shallow sowing can be that when the seeds are sown shallow, the seedlings take less time for emergence through the soil thus giving *R. solani* less time for attacking the susceptible tender parts of the host, and that there are less chances for suitably uniform moisture and temperature range in the surface soil than in the lower depths. These factors reduce the intensity of action by *R. solani* resulting in reduced loss of seedlings which ultimately shows a relatively lower mortality in shallow sown crops than in deep sown crops.

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ROOT-ROT AND WILT OF *CYAMOPSIS PSORALIOIDES* IN RELATION TO THICK AND THIN SOWING OF THE CROP

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In a crowded stand of crops the proper aeration of the soil is checked, humidity and temperature of the atmosphere as well as of the soil are likely to favour the survival and spread of the fungi. The plants remain tender and weak. The soil-borne fungi can easily reach and invade the roots of healthy plants. It is well known in the case of diseases like 'damping-off,' root-rot and wilt that thick stand of the plants leads to greater incidence of these diseases and by proper spacing of the plants the loss may be reduced. In course of the studies on root-rot and wilt of *Cyamopsis psoralioides* DC., caused by *Rhizoctonia solani* Kuhn and *Fusarium coeruleum* (Lib.) Sacc., as affected by the environments and cultural practices (1,2,3), some experiments were carried out to see the effect of thick and thin sowing on the incidence of mortality.

Experimental

The normal seed-rate of *Cyamopsis psoralioides* (*guar*, cluster-beans) varies from 8 to 12 seers per acre. Usually 10 seers of seeds are sown broadcast over an acre of land. However, sometimes the cultivators increase the seed rate with a view to get higher yield of fodder. In these experiments four different quantities of seed, viz., 5 srs., 10 srs., 15 srs. and 20 srs. per acre were used.

To ascertain the extent of incidence of the diseases, the experiments were run in two series consisting of randomised blocks. The soil in one series of beds was not inoculated and the initiation of infection was left to the amount of natural inoculum present in the soil. The soil in the second series of beds was supplied with an additional dose of inoculum in shape of maize-meal-soil cultures of the fungi. There were three replications for each seed-rate in either of the series and the experiments were repeated during 1949—51. The incidence of mortality was recorded under different heads, viz., seedling-rot, root-rot, wilt, and severe or mild leaf-blight (Tables I-III).

Table I. Incidence of seedling-rot, root-rot, wilt, and leaf-blight of *Cyamopsis psoralioides* D. C. in inoculated and uninoculated soil sown with varying seed-rate during 1949.

Series	Seed rate per acre (seers)	Incidence of Mortality (Percent)				
		Seedling rot	Root-rot & wilt	Severe leaf blight	Mild leaf blight	Total Mortality
Uninoculated	5	3·0	4·4	0·6	4·2	8·0
	10	6·5	4·9	1·6	4·7	13·0
	15	10·3	8·7	4·8	6·8	23·8
	20	10·2	14·8	7·5	18·5	32·6

Series	Seed rate per acre (seers)	INCIDENCE OF MORTALITY (Percent)				
		Seedling-rot	Root-rot & wilt	Severe leaf blight	Mild leaf blight	Total Mortality
C. D. at 5 %		1·8	1·4	3·1	5·1	2·7
Inoculated	5	4·4	8·8	1·8	6·8	15·0
	10	10·0	8·7	6·2	7·3	24·9
	15	18·2	13·1	7·8	7·1	40·6
	20	20·0	17·6	14·1	22·4	50·3
C. D. at 5 %		1·3	0·6	1·7	6·2	3·8

TABLE II. Incidence of seedling-rot, root-rot and wilt, and leaf-blight of *Cyamopsis psoralioides* in inoculated and uninoculated fields sown with varying seed-rate during 1950.

Series	Seed-rate (Srs./acre)	DISEASE INCIDENCE (Percent)				
		Seedling rot	Root-rot & wilt	Severe leaf blight	Total mortality	Mild attack of leaf blight
Uninoculated	5	5·1	3·1	1·6	9·8	2·1
	10	9·2	4·1	3·7	17·0	4·0
	15	10·7	8·9	8·2	27·8	5·5
	20	10·3	11·7	8·9	30·9	20·0
C. D. at 5 %		2·8	0·9	2·0	4·1	1·1
Inoculated	5	9·2	6·8	3·1	19·1	5·9
	10	14·0	8·0	10·2	32·2	7·0
	15	23·0	20·4	14·0	57·4	8·3
	20	24·7	26·0	18·0	68·7	22·4
C. D. at 5 %		3·6	1·1	1·9	9·6	2·0

TABLE III. Incidence of seedling-rot, root-rot, wilt, and leaf-blight of *Cyamopsis psoralioides* in inoculated and uninoculated soil sown with varying seed-rate during 1951.

Series	Seed rate (Srs./acre)	DISEASE INCIDENCE (Percent)				
		Seedling rot	Root-rot and wilt	Severe leaf blight	Total mortality	Mild attack of leaf blight
Uninoculated	5	0·9	1·4	0·4	2·9	0·8
	10	1·7	2·3	0·9	4·9	4·5
	15	3·8	4·6	2·5	10·9	6·0
	20	9·5	6·0	4·8	20·3	9·6

Series	Seed rate (Seers/acre)	DISEASE INCIDENCE (Percent) Seedling rot	Root-rot and wilt	Severe leaf blight	Total mortality	Mild attack of leaf blight
C. D. at 5%		3·2	1·8	0·4	2·4	0·7
Inoculated	5	4·0	6·7	1·5	12·2	3·4
	10	5·9	6·1	5·2	17·2	6·0
	15	14·6	11·2	11·0	36·8	6·4
	20	18·2	15·2	13·6	47·3	15·0
C. D. at 5%		4·0	1·6	0·8	6·1	0·9

From the data obtained during 1949-51 it is evident that the total mortality in *Cyamopsis psoralioides* dut to attack of *R. solani* and *F. coeruleum* varies with the quantity of seed sown per unit area of land. The incidence of the individual phases, viz. ,seedling-rot, root-rot and wilt of adult plants; and severe leaf blight is apparently lower in a thin stand than in a thick stand of the crop (high seed rate). There are, however, indications that upto ten seers seed rate these differences are not very significant when analysed statistically. Any increase in the seed-rate above ten seers sharply increases the mortality when compared with the results obtained from the lowest seed rate. The mild attack of leaf-blight, involving partial or complete blight of only individual leaves, has been almost identical in all the treatments except when the seed-rate is twenty seers per acre.

The seed-rates tried in the above experiment covered a very wide range. The practice of sowing the fields at the rate of 20 seers of seed per acre is not very common. Taking two limits which are common to be practised locally the seed rate in another experiment was ranged between four seers and fifteen seers. This experiment was carried out during 1952 in the same plots as used for the preceding experiments during 1949-51. There were four replications for each treatment and the soil was not artificially inoculated with fungus cultures. The results are shown in table IV.

TABLE IV. Effect of thick and thin sowing on the incidence of mortality in *Cyamopsis psoralioides* during 1952.

Seed rate per acre (seers)	PERCENTAGE OF MORTALITY Seedling rot	Root-rot and wilt of adult plants	Severe leaf blight	Total mortality
4	3·0	0·4	0·0	3·4
6	3·9	0·9	0·5	5·3
8	5·4	2·4	1·4	9·2

Seed rate per acre (seers)	PERCENTAGE OF MORTALITY			
	Seedling rot	Root-rot and wild of adult plants	Severe leaf blight	Total mortality
10	6·9	4·0	1·9	12·8
12	7·2	5·7	2·6	15·5
15	9·8	11·6	4·4	25·8
C. D. at 5 %	0·6	0·6	0·4	1·0
at 1 %	0·3	0·9	0·6	1·4

The foregoing data confirm the results obtained during 1949-51. The mortality due to seedling-rot is least in plots sown at the rate of four seers per acre. To be significant at five percent and one percent level the differences between figures for seedling-mortality in different treatments should not exceed 0.6 and 0.8 respectively. Thus the differences between the results of first three seed rates (4,6, and 8 seers) are significant even at 1% level. The percentage of seedlings killed in beds sown at the rate of 10 and 12 seers per acre is identical but a thick stand of the crop in beds sown at the rate of 15 seers of seed per acre suffers the highest rate of seedling-mortality.

The death of adult plants due to root-rot and wilt is identical in plots sown with four and six seers seed rate. For significance the differences between mean figures in this column of the table IV should be less than 0.6 and 0.9. Thus the incidence of root-rot and wilt of adult plants is minimum in beds sown with four and six seers seed rates. The mortality shows significant rise with further increase in the quantity of seeds sown and is maximum in the thickest showing of the experiment.

The number of plants killed due to severe leaf-blight has been negligible in beds sown at the rate of four seers per acre. When the seed rate is raised to six seers the number of plants killed shows an increase which continues with the increase in seed rate. The differences are highly significant.

The figures for total mortality exhibit marked contrast between the results of different treatments. The differences between all the mean figures are significant even at one percent level. Thin sowing has resulted in the least damage to the crop through *R. solani* and *F. coeruleum* as compared to thick sowing.

It has been observed that in beds sown with low seed rate the plants are sharply different in their growth habit from the plants in other treatments. The weight of the top per plant after removing the lower, hard and almost bare stem has been found to be much higher in plants growing in beds sown with 4-6 seers of seed per acre than the plants standing in beds with higher seed-rates (Table V.)

The number and sizẽ of pods formed on such plants is also better than on weaker plants in a thick stand. This suggests that a low seed rate may prove agronomically feasible for fodder as well as for grains.

TABLE V. Average weight of green tops of *Cyamopsis psoralioides* plants from plots sown with different seed rates in 1952.

Sample no. (each with 10 plants)	Weight of green tops (lbs.)					
	Treatments (Seed rate—seers/acre)					
	4	6	8	10	12	15
1	49·5	39·8	35·9	25·0	18·6	12·9
2	54·3	42·5	33·6	20·6	16·1	16·1
3	40·0	40·7	32·9	24·1	18·1	15·0
4	46·3	38·2	32·6	25·0	18·0	13·0
5	50·1	38·9	32·8	24·7	16·0	14·6
6	55·6	38·8	30·9	·120	15·0	14·0
7	42·8	41·2	32·9	19·9	15·0	14·5
8	43·5	36·8	36·6	20·2	15·6	12·8
9	46·6	39·6	32·9	24·2	15·1	13·0
10	42·9	38·6	31·5	23·2	16·0	13·2
Mean weight* of tops from ten plants.	47·2	39·5	33·3	22·7	16·3	13·9

*Critical difference at 5% level 2.6
at 1% level 3.5

Intercultural operations in *Cyamopsis psoralioides* are not practiced unless the crop has been sown for vegetables. Artificial spacing by thinning out the plants is neither economical nor practiced by an average cultivator. However, with a view to duplicating the experiments and getting further confirmations of the results mentioned above the crop was sown in spaced rows and the plants were allowed to grow at a desired distance from each other. The rows were 18 feet long, each two feet apart. Soon after emergence the seedlings were thinned out so that in different replicated rows the plants stood at a distance of less than six inches (no thinning) to 36 inches from each other in the same row. The mean percentages of plants killed in different treatments during 1950-52 have been shown in table VI.

The incidence of mortality due to seedling-rot, root-rot, and wilt has been high till the distance between plants within the row is kept upto six inches. There has been a significant decrease in the incidence of wilt of adult plants when they stand 12 inches apart or at a greater distance. As the plants reach the age of three weeks the original distance of six to twelve inches between them does not help much in keeping the foliage of individual plants away from each other. Consequently, the incidence of leaf-blight is almost identically high when the distance between plants within the row is not more than 12 inches. The adverse effect of spacing on the occurrence of severe leaf-blight is apparent when the plants are 24 inches apart each way. The mortality of plants is lowest when the plants within the row have been spaced at a distance of 36 inches.

TABLE VI. Effect of spacing between plants on the incidence of seedling rot, root-rot, wilt, and leaf-blight of *Cyamopsis psoralioides*

Distance between plants after thinning (inches)	DISEASE INCIDENCE: Mortality due to seedling-rot, root-rot, and wilt 1950	1951	1952	Mortality due to severe leaf-blight 1950	1951	1952
			Percent			
No thinning	14·9	10·0	12·9	4·8	4·0	5·9
6	13·4	8·9	11·0	2·9	3·0	3·4
12	9·3	7·6	9·2	2·6	2·9	2·8
18	6·1	3·8	5·0	1·1	0·6	1·0
24	3·4	1·9	3·1	0·3	0·1	0·2
36	0·9	0·5	1·6	0·0	0·0	0·1
C. D. at 5 %	0·2	0·7	0·6	0·3	0·2	0·3
at 1 %	0·3	1·0	0·8	0·4	0·2	0·4

DISCUSSION

Most of the soil-fungi, causing root-rot and wilt, are known to spread mainly through soil and cause infection through roots. Spacing between susceptible roots is, therefore, one of the best ways to check infection of plants by such fungi. These fungi inhabit a field in scattered colonies and when a low quantity of seed is sown broadcast the probability of contact between the host and the fungus colonies is considerably reduced. This factor minimises the initial infection of susceptible roots. Later on, when the plants are grown up, the distance between individuals due to thin sowing operates through increasing the distance to be covered by the fungus from the original point of infection to other roots. Other factors such as plant-vigour, high soil-temperature and low soil-moisture may also be responsible in adversely affecting the parasite.

Leaf-blight is caused by *R. solani* which grows from the soil on to the leaves touching the ground in early stages of the plant growth. The spread of the disease is favoured by a thick stand when healthy and diseased leaves frequently come into contact. By a good spacing the chances of such a contact are greatly reduced and during a relatively dry weather the appearance of leaf-blight may altogether be absent.

The *Cyamopsis* crop is usually harvested for fodder when the pods are just forming. If given facilities, including sufficient spacing, the plants at this stage have attained a much branched top with luxuriant foliage. This naturally increases the yield of fodder and grain.

Although artificial spacing may not find favour with cultivators for various reasons the results of the above experiments demonstrate the value of thin sowing or spacing between plants in reducing the plant mortality and in increasing the quantity and quality of the yield from a low seed-rate. Instead of artificial spacing by mannual labour the seeds may be planted behind a plough with desired spacing in rows. This will eliminate the cost of thinning operation as well as of extra seeds.

SUMMARY

A low seed rate (4-6 seers per acre) or spacing between plants (24-36 inches each way) helps in minimizing the mortality in crop of *Cyamopsis psoralioides* DC (guar), caused by *Rhizoctonia solani* Kuhn and *Fusarium coeruleum* (Lib.) Sacc. It also increases the yield of fodder and grain.

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STUDIES ON THE EFFECT OF SULPHA-DRUGS ON GERMINATION, GROWTH AND MATURITY OF WHEAT

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Introduction

Sulpha-drugs, commonly used in chemotherapy due to their anti-bacterial activity, are also found to retard growth and development of fungi (6,8,9) and even of higher plants (1 to 4, 7, 10 to 12). However, Grace (7), working with tomato cuttings and various seeds, concluded that "Sulphanilamide in lower concentrations acts like the recognised plant growth chemicals and does possess growth promoting properties; higher concentrations are growth inhibitory." Wielding (11) investigated the action of sulphanilamide on root growth of *Pisum sativum* and *Lupinus* sp. and found suppression of longitudinal root growth at concentrations of 10, 100, 1000 and 10,000 ppm. Macht and Kehoe (10) reported that the growth of *Lupinus albus* was stimulated by sulphanilamide at less than 5 ppm. but was inhibited at 40 ppm. Audus and Quastel (1) observed only the inhibiting effect of different sulpha-drugs on root growth even at as low a concentration as 1 ppm. Some of these drugs are also now reported to check rust infection on wheat (8,9) but the effective concentrations were generally found to cause chlorosis and even necrosis in the host plant (9).

In recent investigations in this laboratory, it was found that pre-sowing soaking of seeds for 24 or 48 hours in 10,000 ppm. of sulpha-drugs resulted in poor germination, high mortality, and aberrant growth; the toxicity varied with the crop plant and also the drug (2,3). It has also been shown that the toxic effect may be minimized by adopting the 'intermittent soaking' technique (4). The present studies investigated the effect of pre sowing soaking of wheat seeds in different concentrations of sulpha-drugs on germination, growth and maturity.

Methods and material

Seeds of wheat C. 591 were kept in petri-dishes, partly immersed in solutions of 10, 100, 1000 and 5000 ppm. of cibazol [2-(p-aminobenzene-sulphonamido)-thiazole], sulphaguanidine [p-aminobenzene-sulphonyl-guanidine monohydrate], and irgafen [N_1-3,4-dimethylbenzyl-sulphanilamide], and in water for 24 hours at 20°-22° C. The dishes were closed by the covers in such a way as to minimize evaporation but allow aeration. At the end of the soaking period, the seeds were sown in pots filled with garden soil. Controls, dry seeds, were sown 24 hours earlier *i.e.*, at the time of commencement of soaking of treated seeds.

Ten seeds were sown per pot on 22nd November, 1953, and four replications were maintained. Four weeks after sowing, the seedlings were thinned to five per pot except in the pots where the total number of seedlings per pot was less than five. The following observations were recorded : (i) sprouting during soaking; (ii) germination in pots; (iii) height of the main shoot upto the base of the last open leaf or to the base of the ear, number of fully open green leaves, and number of tillers (including the main shoot) at (a) seedling stage (four weeks after sowing), (b) shooting stage (ten weeks after sowing), and (c) maturity; (iv) date of ear-emergence; (v) dry-weight of shoots at (a) seedling stage and (b) at harvest; (vi) yield of grain; and (vii) 1,000 grain-weight.

For statistical interpretation, the factorial method of analysis of variance was not followed. It was clear from the values that the nltimate interaction would be significant; so, the standard error of each 'mean' was separately calculated for all the observations. The 'common standard error' was calculated from the different valnes of the various treatments for each observation. The 'critical difference' was calculated from the 'common standard error.' This facilitates a direct comparison of all the treatments. However, it may be noted that the 'critical difference' is fairly high for many of the observations, apparently due to the small number of replications (four). For the sake of brevity, neither the individual 'standard error' nor even the 'common standard error' could be included for any of the observations. (Table II).

The results have also been expressed graphically (Figs. 1 and 2) after calculating the percentages of the values for the different treatments including 'water-soaking' on the value of the respective control ('dry seeds') in each of the observations; the percentages have not been tabulated. In the graphs are also indicated the critical difference (as percentage on the control) in vertical dotted lines with arrow-heads at the ends. The percentages are helpful in following the general effect of the treatments when compared with the control.

RESULTS

Sprouting.—Observations were noted on the sprouting of seeds in the various treatments at the end of the pre-sowing soaking period of 24 hours. The results expressed as percentages on the 'water-soaking' treatment (-0ppm.) are given below as means of duplicates.

TABLE I. Sprouting of wheat seeds in various concentrations of sulpha-drugs. (Percentage on O-ppm., *i.e.*, 'water-soaking').

Drug/Concen-/tration.	10 ppm.	100 ppm.	1,000 ppm.	5,000 ppm.
	%	%	%	%
Cibazol	110·6	89·4	85·1	74·5
Sulphaguanidine	106·4	80·8	70·2	61·7
Irgafen	129·4	117·0	93·6	87·2

Sprouting of the seeds was apparently stimulated by the lowest concentration of the three drugs, it being highest in irgafen and least in S-guanidine. There was a gradual reduction in sprouting with increase in concentration of both Cibazol and S-guanidine. A similar decrease was also observed in irgafen but only the two highest concentrations gave relatively lower sprouting than the 0-ppm.

The results on germination are summarised along with the other observations in Table II as means of four replications *i.e.*, of four pots. In the case of observations on growth and yield the average values per plant per pot are given.

Germination.—Pre-sowing soaking in water (0-ppm.) gave 11% better germination than the control which can be considered as just significant statistically. With regard to the effect of the three drugs germination was generally lowered by an increase in the concentration but the effect was more pronounced with cibazol and S-guanidine. The toxicity of cibazol was clear even with 100 ppm. when germination (58%) was lower than the control (67%) and the 0-ppm. (78%); at the same concentration S-guanidine gave 73% germination and Irgafen 82%. With further increase in concentration to 1000 ppm, germination was affected most by S-guanidine and least with irgafen. At 5000 ppm. cibazol showed a slight decrease, while with S-guanidine germination was as low as 8%. Irgafen on the other hand, maintained fairly good germination even at 5000 ppm; the value (73%) was not significantly different from either the control or 0-ppm.

An apparent stimulatory effect at the lowest concentration (10 ppm.) was observed with irgafen alone; the value (87%) was significantly higher than the control (dry seeds) but was not higher than the 0-ppm. (water-soaking). There was no such stimulating nor even adverse effect on germination with 10 ppm. of cibazol or S-guanidine.

As a result of poor germination in the two highest concentrations (1000 ppm. and 5000 ppm.) of cibazol and S-guanidine the stand of five plants per pot after thinning could not be maintained, as there were only four and three seedlings in 1000 ppm. and 5000 ppm. of cibazol respectively; and two seedlings and one per pot in the respective higher concentrations of S-guanidine. This discrepancy in the stand in these treatments led to certain anomalies in the observations on growth and maturity which have been taken into consideration in the discussion.

Seedling stage (four weeks old).—Except with the lowest concentration of 10 ppm. there was a definite graded depression in the growth of the seedlings as indicated by the height of the plants with increase in concentration; the effect was most pronounced with S-guanidine and least with irgafen. The seedlings from 5000 ppm. of S-guanidine were only 21% in height compared to the control while with the same concentration but of Irgafen the seedlings were 70% as tall as the control. A similar trend was observed both in the case of leaf number as also for the dry-weight although values for dry-weight for the two higher concentrations of cibazol and S-guanidine were not available. Tillering seems to have improved with the higher concentrations of cibazol and with the highest of irgafen; a similar effect was not observed with S-guanidine.

Shooting stage (*ten weeks old*).—The plants were gradually recovering from the adverse effects of the drugs but even so they were still far behind the control, particularly in the cibazol and S-guanidine treatments. The plants of the highest concentration of cibazol or of S-guanidine were only about one-third as tall as the control but in Irgafen the height of the plants was 64% of the control. The recovery in the leaf number was much better than in the height, although the relatively greater toxicity of S-guanidine compared to cibazol, could still be observed in the smaller number of leaves per plant in the higher concentrations. The leaf-measurements (length and maximum breadth) however indicate that even though the leaf number in the lower concentrations of cibazol and S-guanidine or even in all the concentrations of the less toxic irgafen was the same as in control the former were really narrower and occasionally shorter. Tillering apparently continued to improve with the higher concentrations of the drugs compared to the control.

Earing.—It was delayed proportionately with increase in concentration of cibazol and S-guanidine and it was also later than the control by about six days (statistically significant) in the case of 5000 ppm. of irgafen; a delay of 21 days and of 10 days was observed with the same concentration of S-guanidine and of cibazol respectively.

Maturity.—The height of the plants at the maturity stage indicates clearly that they could recover from the adverse effects of even the higher concentrations of cibazol and S-guanidine. On the other hand the heights reached by plants of the Irgafen treatment at 5000 ppm. were only 87% as tall as the control. A similar effect was also observed in the dry-matter formed and in the yield of grain.

The quality of grain as indicated by 1000-grain-weight showed a definite gradual lowering with increase in concentration: the highest concentration of the three drugs gave the lowest quality grain whose 1000-grain-weight was only 74% (Cibazol) 60% (S-guanidine) and 84% (Irgafen) of the control.

DISCUSSION

Attempts were made by several workers to find out whether sulphonamides in low concentrations behave as growth-hormones. Evidence was obtained both in favour (6,10) and otherwise (1, 2). However the technique generally adopted consisted in growing seedlings with a continuous supply of the solution of the drug under study. In the present studies, it was intended to find out the stimulatory or toxic after-effects, if any, due to pre-sowing soaking of wheat seeds in different concentrations of three sulpha-drugs.

Sprouting and germination.—The Graphs I and II, relating to these observations, clearly indicate: (i) the three drugs show adverse effects at different concentrations, thus indicating their relative toxicity; (ii) with the lower concentrations (10 and 100 ppm.) of Irgafen and the lowest (10 ppm.) of cibazol and S-guanidine there is an apparent stimulation of sprouting; but germination was stimulated only by Irgafen; moreover, germination with Irgafen up to 1000 ppm. seems to be better than even 0-ppm. ('water-soaking').

The objection to pre-sowing soaking treatments is generally attributed to the adverse effect on germination. In the present studies, even the toxic concentration of 100 ppm. of S-guanidine gave as good germination as the control (dry seeds).

Growth.—Measurements on height at the three stages of growth (seedling, shooting and maturity) are interesting, in that there was initially general depression in growth as a result of the effect of the drugs, but the plants gradually recovered, so that at maturity they were either equal to the control (43.7 cms.) or even better, particularly with 10 ppm. of cibazol (54.8 cms.). It is also interesting to note that greater the initial depression, relatively better was the recovery which is borne out in general by the figures given below and by the Graphs III, IX and XIII in Figures 1 & 2.

TABLE III. Heights of the plants at different stages of growth. (Percentages on the respective controls).

Growth Stage	Water-soaking (*O-ppm*)	*Cibazol* (*ppm.*)				*S-guanidine* (*ppm.*)				*Irgafen* (*ppm.*)			
		10	100	1000	5000	10	100	1000	5000	10	100	1000	5000
Seedling	91	87	62	32	28	111	81	28	21	104	94	91	70
Shooting	102	101	61	38	32	105	66	28	30	97	90	83	64
Maturity	111	125	97	102	100	111	90	113	118	105	90	97	78

From the above, it is clear that the more toxic cibazol and S-guanidine suppressed the growth in the initial stages, particularly in the higher concentrations, but still the plants recovered finally to the normal height even in the highest concentration. Irgafen, however, showed less intense effect on growth; the adverse effect apparently persisted even upto maturity in the higher concentrations.

A similar tendency is also observed in the case of dry-weight of shoot which was recorded at the seedling and the maturity stages.

Yield and quality of grain.—With 10 ppm. of cibazol and also of S-guanidine there was an apparent stimulation in yield of grain. It may be noted that both the dry-matter of the shoots and also the heights were comparatively better than the controls; such a stimulatory effect was not clear with irgafen. Inspite of the recovery in height at maturity, yield of grain in 100 ppm. of the three drugs was fairly low compared to the control, the values being 55% (Cibazol), 69% (S-guanidine) and 89% (Irgafen) of the control. The values for the two highest concentrations of cibazol and S-guanidine showed discrepancies apparently due to the difference in stand; it was also noted to some extent in the height and in the dry-matter formed in the shoots at maturity.

Quality of the grain, as indicated by 1000-grain-weight, was apparently related to the time of earing; but the grain from 10 ppm. of the three drugs was better than the control, inspite of the slight delay in earing in these treatments compared to the control, as shown below:—

TABLE IV. Time of earing (in days) and quality of grain (1000-grain-weight).

Observation	Control (dry-seeds)	Cibazol 10 ppm.	S-guanidine 10 ppm.	Irgafen 10 ppm.
Earing (Days)	78·3	79·8	79·5	79·3
1000-gr.-wt. (gms.)	32·65	34·44	36·93	35·08

It once again shows the apparent beneficial effect of the lowest concentration of the three drugs not only on growth but even on yield and quality of grain, particularly with Cibazol and S-guanidine.

General.—An initial depression in growth and a later recovery with better yield was noted with a similar pre-sowing soaking treatment with NAA and 2, 4—D at 10 ppm. (5). It may perhaps thus indicate that even synthetic growth hormones may behave like sulphonamides. This may support the contention of Grace (7) that sulphonamides are similar to growth hormones at low concentrations; it is unfortunate that details regarding the concentrations used by him are not available. Audus and Quastel (1) obtained an apparent stimulation in growth with a continuous supply of 1 ppm. of sulphanilamide and sulphapyridine which, however, was considered to be negligible and made them conclude that these drugs do not exhibit growth-promoting properties. The effect of pre-sowing soaking of wheat seeds for 24 hours in 10 ppm. of cibazol and S-guanidine show an apparent stimulation in growth and maturity; the lack of statistical significance may be due to the smaller number of replications. Perhaps a still lower concentration or an increase in replications may show significant stimulation.

SUMMARY

Wheat seeds were soaked in 10, 100, 1000, and 5000 ppm. of cibazol, sulphaguanidine and irgafen for 24 hours prior to sowing, and their effect on germination, growth and maturity was studied in pot cultures. The results were analysed statistically.

Compared to water-soaking, sprouting during the treatment period was stimulated by 10 ppm. of the three drugs and by 100 ppm. of irgafen; but it went down with increase in concentration, the order being S-guanidine cibazol irgafen. Compared to the control (dry seeds),

germination in pots was also lowered with increase in concentration, but the effect was more pronounced with Cibazol and S-guanidine.

A definite depression in growth, as indicated by the height of the main shoot, was observed at the seedling stage which seemed to have diminished gradually, and at maturity the plants recovered almost completely. It was noted that greater the depression, relatively better was the recovery. A similar trend was noted for leaf-number, but the leaf-measurements indicate that they were narrower and occasionally shorter in the treated sets. Tillering was apparently improved by the higher concentrations of the three drugs.

Ear-emergence was delayed proportionately with increased concentration of the three compounds, the order being : S-guanidine>Cibazol>Irgafen.

Compared to the control, yield and quality of grain were apparently better with 10 ppm. of cibazol and S-guanidine. Cibazol and S-guanidine were more toxic than irgafen in the higher concentrations.

The similarity between the effect of presowing soaking of wheat seeds with 2,4-D or NAA (5) and with the sulpha-drugs, relating to the initial depression in growth and later recovery, has been discussed.

Our thanks are due to Dr. S. Sinha, Head of the Department of Botany, for providing facilities and encouragement.

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Fig. 1

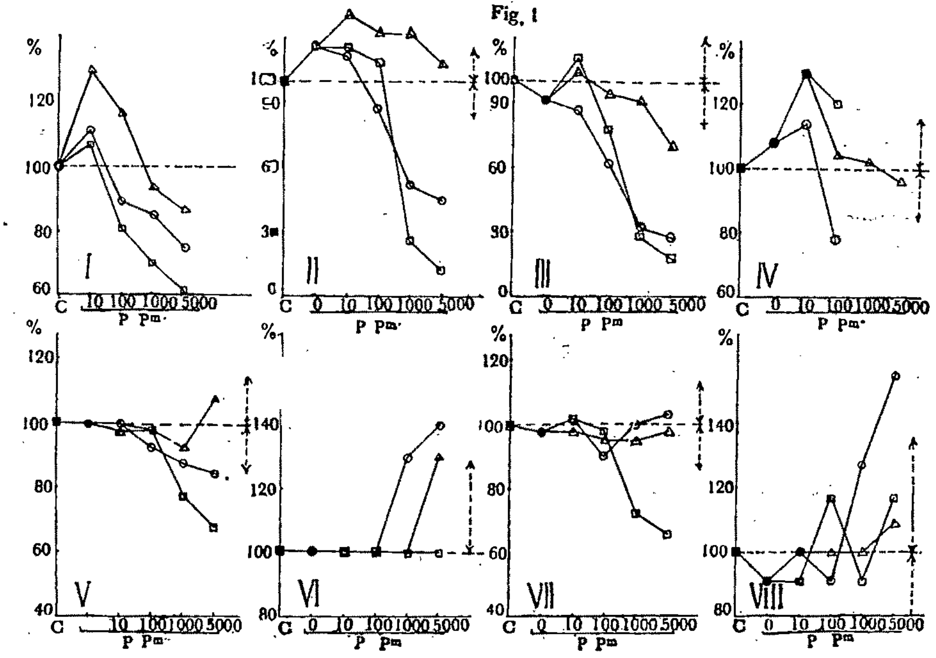
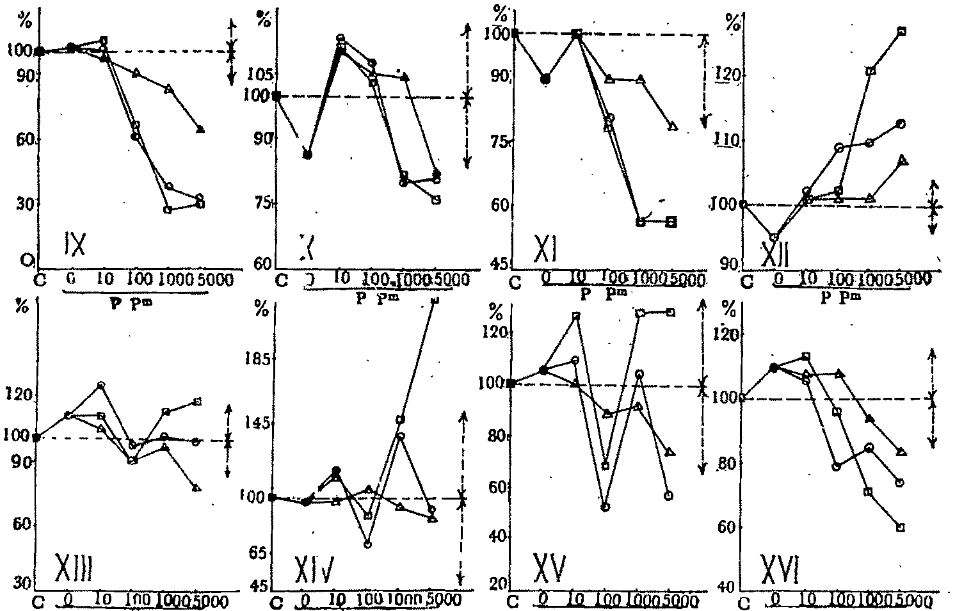


Fig. 2



Graphs : I :—Sprouting ; II :—Germination.
.. III to VI :—Seedling stage :—III : Height; IV : shoot-dry-weight; V : Leaves; VI : Tillers.
„ VII to IX —Shooting stage :—VII : heaves; VIII : Tillers; IX :Height; X : Maximum leaf-length; XI : Maximum leaf-breadth.
., XII :—Ere-mergence.
„ XIII to XVI :—Maturity : XIII ; height; XIV : Shoot-dry-matter; XV : yield of grain; XVI : 1000 grain-weight.

Symbols :

☐ : Control ('dry-seed') ; 0-ppm. ('water-soaking') ;
O : Cibazol ; ☐ : Sulphaguanidine ;
△ : Irgafen ; ‡ : Critical difference.

TABLE II Effect of pre-sowing of wheat seeds in solutions of sulpha-drugs on germination, growth, yield, etc.

(Mean of 4 pots)

Observation	Dry seed (control)	Water	Pre-sowing soaking of seeds in												C.
			Cibazol (ppm)				Sulpha-guanidine (ppm)				Irgafen (ppm)				
			10	100	1000	5000	10	100	1000	5000	10	100	1000	5000	
Germination %	67	78	75	58	35	30	77	73	17	8	87	82	82	73	11
Growth and Maturity : (Mean per plant)															
Seedling stage (4 weeks)															
Height (cms.)	4.7	4.3		2.9	1.5	1.3	5.2	3.8	1.3	1.0	4.9	4.4	4.8	3.3	1.0
Leaf (No.)	4.0	4.0		3.7	3.5	3.4	4.0	3.9	3.1	2.7	3.9	3.9	3.7	4.3	0.6
Tillers (No.)	1.0	1.0		1.0	1.3	1.4	1.0	3.0	1.0	1.0	1.0	1.0	1.0	1.3	0.2
Dry wt. (gms.)	0.050	0.054	0.057	0.039	—	—	0.065	0.060	—	—	0.065	0.052	0.051	0.048	0.0
Shooting stage (10 weeks)															
Height (cms.)	13.5	13.8	13.7	8.2	5.1	4.3	14.2	8.9	3.8	4.0	13.1	12.1	11.2	8.6	2.0
Leaf (No.)	5.9	5.8	6.0	5.3	5.9	6.1	6.0	5.8	4.3	3.9	5.8	5.6	5.6	5.8	0.8
Tiller (No.)	1.1	1.0	1.1	1.0	1.4	1.7	1.0	1.3	1.0	1.3	1.0	1.1	1.1	1.2	0.4
Max. leaf length (cms.)	18.7	16.1	21.2	20.0	15.0	15.2	21.8	19.3	15.2	14.2	20.5	19.6	19.4	15.3	3.1
Max. leaf breadth (cms.)	0.9	0.8	0.9	0.7	0.5	0.5	0.9	0.7	0.5	0.5	0.9	0.8	0.8	0.7	0.2
Earing (Days)	78.3	74.3	79.8	85.3	86.5	80.3	79.5	80·0	94.8	99.3	79.3	79.0	79.3	84.0	2.8
Maturity stage:															
Height (cms.)	43.7	48.5	54.8	54.6	44.6	43.8	48.6	39.3	49.4	51.5	45.9	39.6	42.3	34.3	7.4
Dry matter (gms.)	0.569	0.552	0.662	0.400	0.784	0.530	0.643	0.506	0.849	1.269	0.554	0.599	0.541	0.510	0.3
Yield (gms.)	0.389	0.407	0.424	0.215	0.403	0.232	0.490	0.268	0.496	0.499	0.388	0.348	0.357	0.280	0.1
1,000 gr. wt. (gms.)	32.65	35.78	34.45	25.85	27.90	24.18	36.93	31.48	23.18	19.53	35.08	35.25	30.58	27.50	4.8

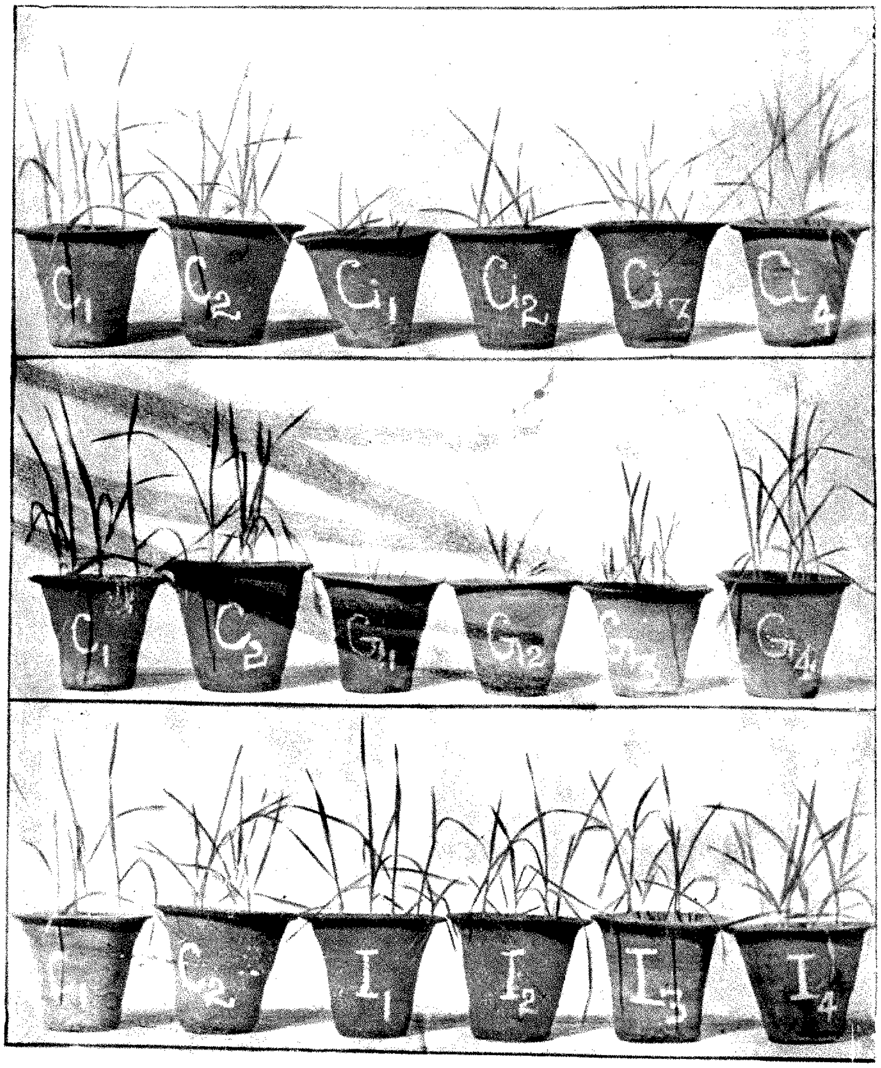
Replications: 4 pots ; 5 plants per pot except : Cibazol :—1000 ppm.=4, 5000 ppm=3; Sulpha-guanidine:—1000 ppm.=2, 5000 ppm.=1.

C. D. Critical difference.

PLATE XIV

Effect of Sulpha-drugs on seeding growth in wheat.
Top row : Controls and Cibazol treated plants
Middle row : Controls and S-guanidine treated plants
Bottom row : Controls and Irgafen treated plants.
Controls :C_1: 'Dry seed'; C_2 : '0-ppm' ('water-soaking')
Cibazol : Ci_1. Ci_2, Ci_3, Ci_4 :—5000, 1000, 100, 10 ppm.
S-guanidine : G_1, G_2, G_3, G_4, :- G,, ,, ,, ,, ,,
Irgafen : I_1, I_2, I_3, I_4,:— ,, ,, ,, ,, ,,

PLATE XIV



THE LIFE-HISTORY AND ECOLOGY OF THE NORTHERN SPOTTED GRASSHOPPER, *AULARCHES PUNCTATUS* DRURY (ORTHOPTERA : ACRIDIDAE)

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(With 1 Plate & 7 Tables).

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I. INTRODUCTION

The Northern Spotted Grasshopper *Aularches punctatus* Drury feeds both in the hopper as well as adult stages on various plant species. It is fairly common in Dehra Dun and is found especially damaging "carihari" (*Gloriosa superba* Linn. family Liliaceae), young teak (*Tectona grandis* Linn. F. family Verbenaceae) and various types of thorny bushes. During recent years it has been observed that *Aularches punctatus* is becoming a pest of the two species mentioned above. Besides these, it attacks tea-plantations, paddy, and maize and sometimes nursery plants. A detailed study of its life-history and ecology was made during the last three years, and the results are presented in this paper.

Much work has been done on the allied species, *A. miliaris* Linn., by the following authors in Ceylon and Travancore:—Green, 1906; Lefroy, 1909; Hingston, 1927 ; Hutson, 1936, 1928, 1935; Huntley 1936; Jones 1940 ; and Mc Cann 1953.

ACKNOWLEDGMENTS

This work was done in the Entomology Branch of the Forest Research Institute, Dehra Dun, under the guidance of Major Dr. M. L. Roonwal, Forest Entomologist. The author is much thankful to him for many valuable suggestions.

II MATERIAL AND BREEDING TECHNIQUE

A large number of adults of *Aularches punctatus* Drury were collected in the months of July and August, 1951, in New Forest Estate (Dehra Dun),

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TABLE I. MONTHLY TEMPERATURES AND HUMIDITY DURING THE YEARS 1951-1952 IN THE INSECTARY-ROOM AT NEW FOREST, DEHRA DUN.

Month	Range of temperature and humidity in 1951				Range of temperature and humidity in 1952			
	Temperature (°F.)		Average relative humidity (%)		Temperature (°F.)		Average relative humidity(%)	
	Maximum	Minimum	At 9-30 A. M.	At 4-30 P. M.	Maximum	Minimum	At 9-30 A. M.	At 4-30 P. M.
anuary	52.0—58.5	44.5—52.9	83.04	74·6	53.0—62.9	45.5—54.0	81.4	70.05
ebruary	55.0—67.5	45.0—56.0	75.6	63.9	58.5—68.5	48.0—58.0	77.3	64.7
arch	63.5—72.5	55.0—63.5	71.3	60.5	62.0—74.3	52.5—64.5	76.7	67.0
pril	68.5—83.5	57.0—73.0	62.3	58.6	71.5—89.0	60.5—79.0	68.3	56.1
ay	79.0—92.0	67.0—85.0	60.0	46.3	82.0—96.5	72.0—87.5	62.9	55.3
une	80.0—94.5	73.0—89.5	57.6	49.7	80.0—94.9	72.0—87.0	76.8	68.8
uly	81.5—90.5	74.0—84.0	76.5	75·9	80.0—87.5	74.0—80.5	87.3	79.5
ugust	76.5—84.9	73.9—79.0	87.1	84.5	78.5—85.5	74.5—78.5	90.5	89.4
eptember	76.5—84.5	70.5—77.5	84.3	80.5	81.0—84.0	70.5—76.5	85.6	78.5
ctober	74.5—80.5	64.0—73.0	81.4	74.2	69.0—80.5	60.0—71.5	77.2	70.8
ovember	61.5—73.5	52.3—62.0	80.1	70·5	60.9—74.5	49.5—60.5	74.7	65.8
ecember	56.3—62.8	47.0—55.0	87.08	77.3	55.0—63.5	45.5—52.0	75.0	68.9

and its vicinity. They were caged in a large glass trough, with a 3-4 inch layer of sandy-loam. Egg-pods were obtained from them in late, September 1951. Later on, all the egg-pods were kept under a 3-inch thick layer of soil in two earthern flower-pots which were covered with fine wire-gauze. The nymphs hatched out next April. The hatched nymphs were kept in wooden cages with wire-guaze sides and measuring 24 x 12 x 12 inches. They were supplied daily with fresh, tender grass which was kept dipping in a bottle of water. The breeding was carried out in the Insectary at a room temperature of 73°—92° F. from September to December. The average monthly temperatures and humidity are given in Tables I and II.

For observations of moults, etc. some hoppers of the first stage were kept individually in glass tubes (6 x 1½ inches) fitted with cork having a muslin covered hole for aeration. These hoppers also were supplied with green grass; occasionally, when green grass was not available, moist bran was given. Simultaneously with laboratory breedings, records of field observations were maintained from July, 1951 to December, 1953 (Table III-VI).

III. HABITS AND LIFE-HISTORY

(a) *Habits*

Adults and hoppers of *Aularches punctatus* congregate in masses on tree-tops and bush-tops to bask in the rays of the sun early in the morning. They disperse on the falling on them of the shadow of a person. If a single individual in the mass is touched by hand or stick, all hoppers and adults in that mass jump down quickly and scatter into dark places in groups of twos and threes, or sometimes more, and when the apparent danger is over, they begin to re-assemble. In the Insectary cages it was noticed that whenever one hopper or adult in a mass was touched, almost all the members of the mass simultaneously moved their legs and dispersed in different directions in smaller groups. In the morning, when it is cooler, the nymphs and adults remain dull and sluggish, but as the air temperature rises with the advancing day, they become active.

The newly hatched nymphs confine their eating to tender portions of the leaves only. In the initial stages they make small cuts all over the leaves, leaving only the veins and petioles. However, when the nymphs grow old they eat all parts of the leaves.

Both hoppers and adults are gregarious. They are always observed in masses on the low bushes and trees in the field. They also occur in masses on the leaves of teak (*Tectona grandis*) at a height of 15-40 ft., and behave likewise on the leaves in the cages and on the ground.

When adults are caught they emit a black offensive—smelling fluid from the following places:—1. Thorax close to the base of the hind-legs. 2. Base of the front-legs. 3. Posterior margin of the metanotum. Hingston (2) observed in *A. miliaris* that the fluid is usually clear as water, but sometimes turbid or faint yellow.

TABLE II. MONTHLY TEMPERATURES AND HUMIDITY DURING THE YEARS 1951-1952 IN THE FIELD AT NEW FOREST, DEHRA DUN.

onths	Range of temperature and humidity in 1951						Range of temperature and humidity in the year 1952					
	Temperature (°F.)		Temp. of the day (corrected & averaged)	Relative Humidity at 8 A M (in %)			Temperature (oF)		Temp. of the day (corrected & averaged)	Relative Humidity at 8 A.M. (%)		
	Maxim.	Minim.		Maxim.	Minim.	Average	Maxim.	Minim.		Maxim.	Minim.	Average
uary	53.8-71.6	36.6-48.5	53.3	59.5	49.7	63	53.0-75.6	39.7-54.0	56.6	96	46	70.0
bruary	61.0-82.0	37.8-52.8	57.5	63.5	50.7	49	63.0-83.0	44.0-55.5	61.4	86	44	64.1
arch	69.0-88.0	47.2-58.5	65.1	93	27	41	66.0-84.9	46.2-58.3	64.7	97	35	62.2
ril	78.1-97.2	48.0-67.7	71.6	54	18	31.2	78.0-101.3	52.6-73.0	79.7	69	25	39.9
ay	86.8-106.4	56.6-77.0	80.8	90	15	33.7	85.9-108.0	64.0-73.1	83.3	90	19	39.4
ne	87.0-108.3	63.5-84.0	84.5	59	19	37.5	81.8-106.0	66.0-82.0	82.3	95	29	61.9
ly	81.0-99.0	68.2-78.0	81.6	98	60	69.8	83.0-94.0	70.0-76.8	80.7	98	73	85.9
ugust	81.0-93.7	70.7-78.8	79.9	100	59	82.9	76.5-92.2	72.6-76.8	78.8	100	73	90.3
ptember	79.0-93.0	66.6-74.9	70.3	93	61	74.7	84.7-93.2	63.6-73.7	76.7	98	58	72.4
ctober	84.3-92.0	56.7-77.0	74.9	86	47	62.0	83.0-90.2	53.2-67.0	72.1	68	37	53.7
ovember	69.0-84.4	45.5-70.8	64.9	90	42	60.9	77.2-88.4	42.5-59.0	63.2	62	37	51.6
ecember	67.8-75.8	40.7-51.1	58.0	80	53	67.7	65.7-76.0	39.0-50.8	56.7	91	43	61.7

(b) *Copulation* (Table III)

Both males and females reach maturity at about the same time. In the Insectary the, first copulating pair was noticed 12 days after the last moult, *i.e.*, on the 13th August 1951; another one was seen on the 18th August in the field. The mating period lasted from the 2nd week of August to the 1st week of October. The maximum number of mating pairs are found during the last week of August and the first week of September (Table III).

The method of copulation is briefly as follows:—The excited male clasps the female from the back; sometimes two or three males were seen clasping a single female in order to go on her back for coitus. Copulation takes place by Mode I *i. e.*, the riding mode (*vide* Katiyar, 8). The male rides on the female head to head, and terminal ends of the two abdomens interlock with each other, the male abdomen bending down to either the left or the right of the female abdomen to achieve the coitus. Usually the males remain on the back of females even after coitus is over and while the latter are in the act of ovipositing. Both male and female go on feeding during copulation.

(e) *Oviposition* (Table IV & V)

Oviposition was recorded from September 10 to October 12, in 1951; and from August 25 to October 4, in 1952. The maximum number of ovipositions were observed during the 2nd week of September in 1951 in the Insectary, and from 27th September to 7th October in the field during 1951-52 (Table 4).

Eight to fifteen days after copulation, the females begin to look "lazy" and are noticed either brushing their abdomen with the hind-tibia or making holes in the soil with their ovipositor. After making 3 or 4 trial holes, the final hole for oviposition is made. The females insert the abdomens slowly into the moist soil. Almost all the females make an angle of 135° -140° with their abdomen on the surface of the soil. The act of oviposition lasts usually about 3 to 4 hours or a little longer; in a few cases only ½ to 1 hour (Table V). After oviposition almost all the females were seen levelling off the holes left on the surface of the soil with the aid of the ovipositor valves and the hind-legs.

A female may lay eggs as many as 3 times and does not die just after oviposition as in *A. miliaris* Linn. (Jones, 1940). The egg-pods are laid very close to each other. The number of eggs in the egg-pod varies from female to female, and usually there is a decreasing number with subsequent egg-layings by the same female. In the first-laid egg-pods, the number of eggs varies from 96-120; in the second lot from 90-98; and in third lot from 78-81, with an average of about 98 eggs per pod (Table VII) for the three lots.

(d) *Location of the egg-pods in the field*

Around Dehra Dun, the egg-pods were dug out from 1-3 inches below the soil surface in sandy-loam along the banks of the rivers Tons, Nimme and

Raspana under thorny plants; very close to the high base of dense bushes; and around the bases of the teak trees in Experimental Plots in the New Forest Estate. Once, in the last week of May, 1952, hoppers were found on the dense bushes along the road leading to Mussoorie; the soil of this locality is very hard and gravely. A few egg-pods were obtained under the thorny bushes in between the roots near the Forest Rest House in the Jhajra forest near Dehra Dun. From these instances it appears that the nature of the soil (ground) is no hindrance to egg-laying. Similarly, no preference appears to be shown to any particular type of soil as by *A. milliaris* (Jones, 1940).

(e) *Description of egg-pods and eggs* (Fig. *a*).

In the Insectary the egg-pods are laid 2.5—3.0 inches below the surface of the soil and each egg-pod is about 2.0 to 3.5 inches long. They are almost straight and cylindrical and have a flat anterior end. The outer wall is composed of a thin, pink, frothy layer all around with a 1-1.2 inch long cap of similar material above the eggs. Fine particles of sand stick to the froth externally and give the egg-pod a "dirty" appearance.

The eggs are arranged vertically and irregularly, with their posterior or micropylar poles pointing towards the base of the egg-pod. The fully developed eggs, taken from ovaries, are translucent-yellow. Just after oviposition, they are pale-yellow; later-on they change to dark brown.

In every egg the micropylar ring is distinctly noticeable, being darker than the rest of the egg-surface. The anterior pole of the egg is round; the posterior one is comparatively tapering but is more or less flat at the extremity. The eggs vary in length from 7.0-7.25 mm. (average 7.13 mm.), and in maximum width from 1.8-2.0 mm. (average 1.93 mm.), The eggs gradually increase in size with the development of the embryo within; the eyes of the developing embryo become conspicuous sometime before hatching.

(f) *Hatching.*

At the time of hatching, the egg-chorion becomes "dry" and splits longitudinally. Hatching generally occurs from the end of April to the beginning of June and lasts about 8-9 weeks, the exact period varying from year to year, depending upon the weather conditions.

Egg-pods obtained from the fields in September, 1951, were placed in two different earthen pots containing sandy soil. The soil in one pot was kept moist while that in the other was kept dry. Almost all eggs from the moist soil hatched out in the following year in April, while no hatching was observed in the other pot. When the soil in the latter was re-moistened in January, 1953, onward hatching took place in the first week of May, 1953; in this lot only two-thirds the number of eggs hatched; the rest had shrivelled up and died.

TABLE III. MATING RECORD IN *Aularches punctatus* DRURY DURING THE YEARS 1951 AND 1952 IN DEHRA DUN.

Number of pairs mating (1951)			Numbet of pairs mating (1952)		
Dates	In Insectary	In field	Dates	In Insectary	In field
13-8-51	1	—	18-8-52	2	—
15-8-51	2	—	22-8-52	4	—
18-8-51	4	—	25-8-52	3	5
20-8-51	3	—	29-8-52	2	16
23-8-51	4	7	4-9-52	13	8
25-8-51	9	—	7-9-52	4	—
28-8-51	6	4	12-9-52	—	2
31-8-51	11	7	19-9-52	1	4
7-9-51	3	11	21-9-52	2	2
9-9-51	2	—	23-9-52	2	1
11-9-51	—	2	27-9-52	1	1
21-9-51	—	3	4-10-52	—	2
28-9-51	1	2	7-10-52	—	2
1-10-51	—	1	...	...	...
Total pairs from 13-8-51 to 1-10-51.	46	35	Total pairs from 18-8-52 to 7-10-52	34	43

(*g*) *Moulting*

Aularches punctatus undergoes six moults in both sexes; this was so in the Insectary as well as in the field. Moulting was observed from early morning up to 2 P. M.; hardly one or two cases were noticed in the latter part of the day; but no record was taken at night.

Moulting was observed in the Insectary hoppers from 1st stage to adult (Table VI). The duration taken by each stage is as follows:—

1st stage, 12-13 days; 2nd stage, 10-12 days; 3rd stage, 13-16 days; 4th stage, 12-14 days; 5th stage, 13-16 days; 6th stage, 16-19 days.

IV THE NYMPHAL STAGES

(i) *Description of the stages*

(Figs. *b-g*)

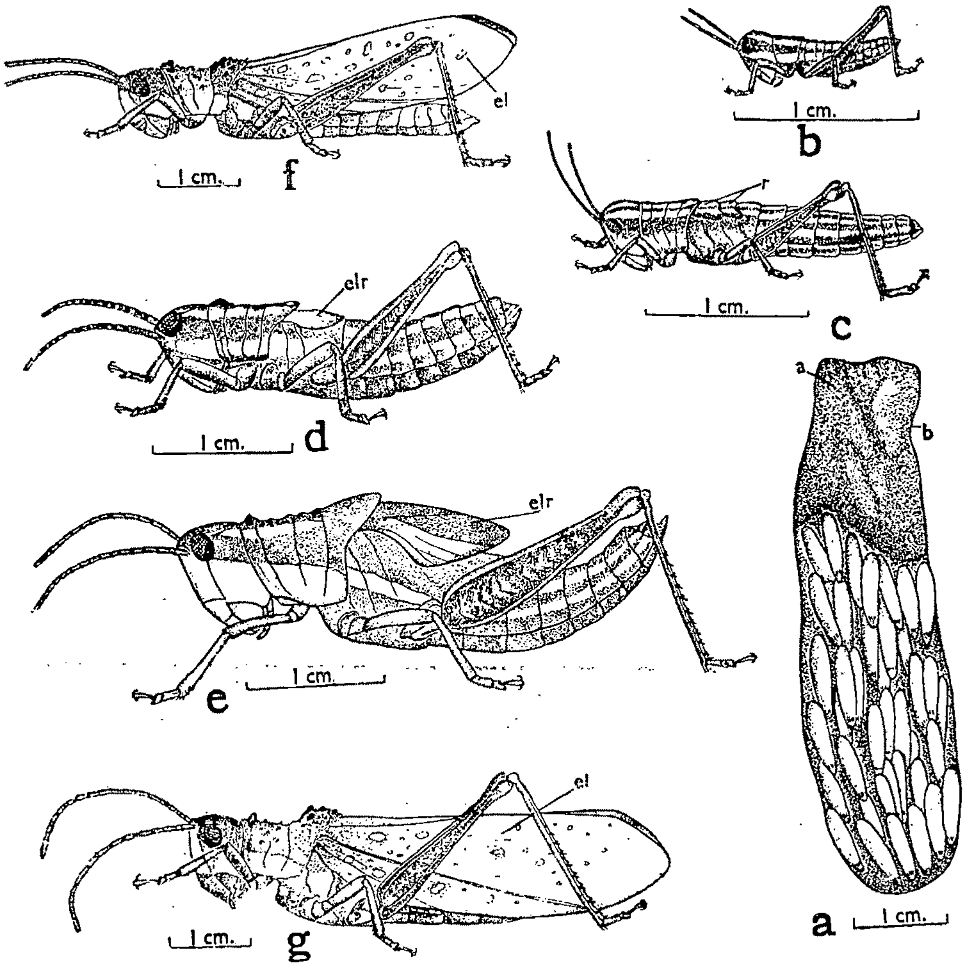
In both sexes, *Aularches punctatus* has, as studied in the Insectary cages, six nymphal stages followed by the adult stage; the same number was noticed in the field from all the localities around Dehra Dun (Table 5). Both males and females reach the adult stage at about the same time. The different stages are described below:—

First stage. General : Freshly hatched nymphs yellowish, later on changing to reddish, and, finally, to dark fuscous. A median-dorsal, thin, yellowish-white stripe present from fastigium to penultimate abdominal segment; on either side of this stripe runs a thick, dark brown band with a pair of spots in cephalic and caudal margins of prothorax; below this lie a yellowish-white, a dark brown, and again a yellowish-white band. Each abdominal segment, except the last one, with a pale spot dorsally. *Head* : All the dark brown and yellowish-white shades of the thorax run anteriorly and meet at the vertex. Viewed from anterior side of head, a yellowish-white band present just above mouth-parts; another horse-shoe shaped yellowish-white band present just above the later. *Legs* : The two anterior pairs fuscous-white; the hind pair black with a white streak on each tibia on outer side. *Antennae*: Dark brown (for fuller description, see Katiyar, 9). Average length in male, 7.5 mm; females 9.0 mm. Wing-rudiments in the meso-and metathorax indistinct. Cerci conspicous on the supra anal plate which is round in both sexes. Females with rudimentary buds of ovipositor on eighth abdominal sternum, while males have a single notch on the rounded supra anal plate (Plate 1, Fig. *b*).

Second stage. Nymphs reddish. Body-markings, described in the first stage, are now more definite. Prothorax curves round dorsally. Rudimentary wing-pads bulge on the meso- and metathorax. Cerci of both males and females develop less in proportion to other parts of abdomen. Sexes easily distinguishable, subgenital plate of male rounded; valves of ovipositor of females easily seen. Average length of males 12.8 mm.; females 14.25 mm.

Third stage. Nymphs generally testaceous in colour. The pale white and reddish-yellow lines and spots become more definite and distinct than in previous stage. Rudimentary wing-pads easily visible, pointing downwards and have indistinct venation. Subgenital plate of male more rounded and protruded beyond last abdominal segment; ovipositor valves of female plainly visible. Average length of males 14.75 mm.; females 17.75 mm.

Fourth stage. General colour black. *Dorsal side*: Head and body with alternate white and black lines as in first stage. A pair of brownish or yellowish spots present on either side of median-dorsal white streak on cephalic and caudal



Aularches punctatus Drury:

(*a*) Egg-pod, showing arrangement of the eggs. (*b*) First stage hopper. (*c*) Fourth stage hopper. (*d*) Fifth stage hopper. (*e*) Sixth stage hopper. (*f*) Adult male. (*g*) Adult female.

Lettering: *a*. soft apical spongy cap of the egg-pod; *b*. soft wall of the compressed spongy material in egg-pod; *el*., elytron; *elr*., rudimentary elytron; *r*., rudimentary wing-pads.

TABLE IV. EGG-LAYING RECORD IN *Aularches punctatus* DRURY DURING THE YEARS 1951 AND 1952 IN DEHRA DUN.

Number of females ovipositing (1951)			Number of females ovipositing in the field (1952)	
Dates	In Insectary	In field	Dates	
10-8-51	4	—	25-9-52	1
11-8-51	2	—	28-9-52	1
15-9-51	—	3	14-9-52	1
16-9-51	2	—	17-9-52	1
17-9-51	—	2	21-9-52	4
18-9-51	1	—	26-9-52	9
24-9-51	1	15	28-9-52	5
27-9-51	—	8	30-9-52	7
28-9-51	1	—	3-10-52	11
1-10-51	1	5	5-10-52	8
9-10-51	1	2	7-10-52	3
12-10-51	—	1	14-10-52	1
Period of maximum oviposition.	10th to 16th Sept.	24th Sept. to 1st Oct.		21st Sept. to 7th Oct.

margins of prothorax, the streak becoming invisible in the last few abdominal segments; the brownish or yellowish spots becoming prominent from 1st to 8th abdominal segments. Below this, a yellowish-white, a dark brown, and again a white band, also become very prominent and are broader than in previous stage. Wings point downwards; venation clearer than in third stage. *Ventral side*: Head blackish; thorax fuscous; abdomen black with a ventral white stripe commencing at metasternum. Anteriorly, a yellow or a brownish spot above the eyes; a white, or in some cases red, streak present in between eyes. Male genitalia red, more rounded and extending beyond the apex of supra anal plate. In females, the red valves of ovipositor also extending beyond apex of supra anal plate; tips of valves black. Average length of males 22.5 mm; females 25.75 mm.

Fifth stage. General colour black. All body-markings more prominent than in previous stage, and the yellowish or the brownish bands change to blackish. Thoracic region more prominent, with two thick, rough ridges medially. Wing-pads now *turned upwards* and extend posteriorly up to 2nd abdominal segment; with prominent venation. Average length of males 27.75 mm.; females 32.25 mm.

This upturning of the elytron- wing complex takes place after the fourth moult, *i.e.*, in the fifth chronological instar, which confirms the *rule* 2. of Roonwal (12, 13).

Sixth stage. Body shining black. Median-dorsal line quite narrow, in some cases indistinct. Other lines pale-white and reddish-black, becoming thicker. The pale-white sublateral bands are triangular on each wing; the bands are subsequently developed into a single one on the supra anal plate dorsally. Other body-markings comparatively more distinct. Upturned wings extend posteriorly beyond 3rd abdominal segment; venation more prominent than in previous stage. Cerci larger in males than in females. Average length of males 36.25 mm., females 43.0 mm.

Seventh stage (adult). Just after sixth moult, adults of both sexes appear creamy-yellow. After a few hours they acquire the permanant colour as follows:-- The spotted wings extend well beyond the abdominal tip, covering the genitalia in both sexes. Head : Black, with a white or red band on vertex in between the eyes. Thorax: Very rough, with two well marked dorsal ridges. Wings black with many yellow spots; venation whitish. Legs : Black; hind-legs with a series of 5-8 triangular red spots on outer side of tibia instead of the whitish streak of the first stage. Ventral side : Head and thorax black; males bear a bright red spot in middle of metasternum. Abdominal segments black, with red caudal margins in both sexes. External genitalia red in both sexes; in females, tips of ovipositor valves black. Cerci larger in males than in females. Average length of males 43.5 mm., females 55.5 mm.

(ii) *Key to the instars*

The key is applicable in the normal development when 6 moults occur. Sometimes, there is an extra stage after the third moult; this extra stage is similar to the chronological third stage, except that it is larger and has definite markings in the wing-venation. The directional reversal of the elytron-wing complex takes place in the fifth stage as described above. It is thus clear that the fifth stage of 6-moult individuals is morphologically equivalent to the fourth stage of 5-moult grasshoppers (Figs. b-g).

The last two stages of the 6-moult individuals, i.e., the sixth stage and the seventh (or adult) stages, develop similarly to the fifth and sixth (or adult) stages of the 5-moult grasshoppers, where the directional reversal of the elytron-wing complex takes place in the fourth stage.

1 (12).	Tegmina and wings wanting or rudimentary	NYMPHS.
2 (9).	Wing pads point *ventral*; antennae 10-16 segmented ...	
3 (6).	Venation of wing-pads wanting; antennae 10-12 segmented.	
4 (5).	Wing-pads not developed; antennae 10 segmented	*1st stage*
5 (4).	Wing-pads developed (slightly); antennae 12 segmented	*2nd stage*
6 (3).	Venation of wing-pads weakly to distinctly indicated; antennae 14-16 segmented.	
7 (8).	Venation of wing-pads weakly indicated; antennae 14-segmented	*3rd stage*
8 (7).	Venation of wing-pads distinctly indicated; antennae 16-segmented	*4th stage*
9 (2).	Wing-pads point *dorsal* (*upturned*) but still-small, not extending beyond tip of abdomen.	
10 (11).	Upturned wing-pads extending to, or slightly-beyond, the caudal margin of metathorax; venation distinct; antennae 16-17 segmented.	*5th stage*
11 (10).	Upturned wing-pads extending well beyond the caudal margin of 2nd abdominal segment; venation very distinct; antennae 17-segmented.	*6th stage*
12 (1).	Tegmina and wings fully developed; extending well beyond tip of abdomen; genitalia completely formed; antennae mostly 17-segmented	*7th stage* (ADULT)

V FOOD PLANTS

Both nymphs and adults feed on green leaves and grasses. They prefer the leaves of teak (*Tectona grandis* Linn. Verbenaceae) and various types of thorny bushes growing along the banks of the rivers around Dehra Dun. During the rains, the hoppers prefer "Carihari" (*Gloriosa superba* Linn. Liliaceae), which is a small, poisonous medicinal plant growing in abundance near the banks of the rivers and in forests around Dehra Dun.

The hoppers were supplied and ate with relish the common green grasses in the Insectary cages; they were also noticed to relish leaves of maize (*Zea mays*, Graminae); pumpkin (*Lagenaria vulgaris*, Cucurbitaceae), and beet (*Beta vulgaris*, Chenopodiaceae). They also accepted moist bran when green foliage was not available.

VI. SEASONAL LIFE-HISTORY IN DEHRA DUN

It is not possible to generalize the seasonal periods of various processes like copulation, oviposition, hatching, development of the nymphal stages, etc., as they vary somewhat from year to year due to varying weather conditions. However, the following brief account will give a fair idea of the seasonal life-history in Dehra Dun.

In Field	In Insectary
1. *Copulation* (Table 3). Form 23rd August to 7th October (nearly 45 days); mostly first week September.	1. *Copulation* From 13th August to 28th September (nearly 46 days); mostly last week August.
2. *Oviposition* (Table 4). Form 15th September to 14th October (about 29 days); maximum: 24th September to 5th October.	2. *Oviposition* (Table 4). From 10th September to 1st October (about 21 days); maximum during 2nd week September.
3. *Hatching*. From 1st week May to 3rd week June; maximum during 2nd week May, in 1951; 2nd and 3rd week May in 1952.	3. *Hatching* From 30th April to 24th May, in 1951; 11th May to 8th June, in 1952; That is, from last week April to 1st week June. Peak hatching: last week April and 1st May.
4. *Hopper stages* Available in the fields I stage : 9 v. 52 to 23. v. 52. (15 days) II stage : 21. v. 52 to 8 vi. 52. (18 days). III stage : 5. vi. 52 to 23. vi. 52. (19 days). IV stage : 18 vi. 52 to 15. vii. 52 (28 days). V stage : 8. vii. 52 to 5. viii. 52. (28 days). VI stage : 21. vii. 52 to 15. viii. 52. (25 days). VII stage : 5. viii. 52 to 14. ix. 52. (40 days).	4. *Hopper stages* (Table 5) From the breeding record I stage : 3. v. 52 to 15/16.v.52. (12-13 days). II stage : 15/16. v. 52 to 26/27. v. 52. (10-12 days). III stage : 26/27 v. 52 to 9/12. vi. 52. (14-16 days). IV stage : 9/12. vi. 52 to 21/26. vi. 52. (12-14 days). V stage : 21/26. vi. 52 to 5/10. vii. 52. (in all cases 14 days). VI stage : 5/10. vii. 52 to 22/28. vii. 52. (16-19 days). VII stage : Almost all became adult on or about 28.vii. 52.
5. *Adult stage* Males and females lived up to last week September in 1951; and 1st week October in 1952.	5. *Adult stage* Males mostly died in last week in September; females lived up to 12th October

VII, NATURAL ENEMIES

Both in field and in the Insectary no natural enemies like birds, lizards or ants were observed. Birds were occasionally observed to attack and catch hold of the hoppers or adults, as the case may be, but soon dropped them; this might be due to the black offensive liquid exuded by them (*vide* above). Eggs were observed free from insect enemies. One pod was attacked by a fungus as a result of which about two dozen eggs shrivelled, turned black and did not hatch.

VIII. SUMMARY

1. *Aularches punctatus* Drury is very common in the area where thorny bushes are in abundance along the banks of the rivers around Dehra Dun. It feeds on green grasses and the leaves of teak (*Tectona grandis*) and also does considerable damage to the medicinal plant "carihari" (*Gloriosa superba*). It also attacks nursery plants, tea-plantations, maize and paddy. Nymphs and adults are gregarious.

2. Mating takes place from the second week of August up to about the 1st week of October Eggs are laid from September to October and hatch after six to eight months. Development of nymphal stages is quite slow. The life cycle is annual.

3. Usually, 6-moults occur, the adult being the 7th stage; occasionally, there is an extra moult in the third stage.

4. Hoppers from 3rd to 6th stage as well as the adults exude a black offensive smelling liquid at the base of their fore and hind-legs and from the posterior margin of the mentanotum.

5. The species is quite hardy and is free from natural enemies like ants, lizards, birds, etc.

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TABLE V. Details of egg-laying in *Aularches punctatus* Drury in the Insectary in Dehra Dun, during 1951.

Individual Females under observation.	1st egg-laying				2nd egg-laying				3rd egg-laying			
	Date	Time	Duration	Number of eggs in a pod	Date	Time.	Duration	Number of eggs in a pod	Date	Time	Duration	N umber of eggs in a pod
A	10-9-1951	2.12 to 5.38 P.M.	3 hrs. 26 mts.	120	12-9-1951	11.45A.M. to 2.27 P.M.	2 hrs. 42 mts.	90	18-9-1951	3.00 to 4.50 P.M.	1 hr. 50 mts.	
B	,,	3.15 to 7.23 P.M.	4 hrs. 8 mts.	100	15-9-1951	1.10. to 3.52 P.M.	2 hrs. 42 mts.	92	...	...	...	...
C	,,	3.20 to 6.55 P.M.	3 hrs. 35 mts.	108	12-9-1951	12.50 to 3.20 P.M.	2 hrs. 30 mts.	92	15-9-1951	2.10 to 3.30 P.M.	1 hr. 20 mts	78
D	,,	3.27 to 7.5 P.M.	3 hrs. 38 mts.	118	15-9-1951	11.10 A.M. to 1.15 P.M.	2 hrs. 5 mts.	98	...	...	...	...
E	11-9-1951	12. 15 2.57 P.M.	2 hrs. 42 mts.	99	,,	1.35 to 3.52 P.M.	2 hrs. 17 mts.	90	...	...	...	...
F	,,	1.00 to 4.2 P.M.	3 hrs. 2 mts.	92	,,	10.50 A.M. to 1.15 P.M.	2 hrs. 25 mts.	90	...	...	...	...
G	16-9-1951	11.5 A.M. to 1.57 P.M.	2 hrs. 52 mts.	102	18-9-1951	1.21. to 3.40 P.M.	2 hrs. 19 mts.	88	...	...	...	...
H	16-9-1951	12.20 to 3.10 .PM.	2 hrs. 50 mts.	111	...	...	...	...	...	...	...	...
I	18-9-1951	11.25 A.M. to 2.30 P.M.	3 hrs. 5 mts.	116	...	...	...	...	...	...	...	...

TABLE VI. PERIOD TAKEN BY *Aularches punctatus* DRURY FOR ITS DEVELOPMENT FROM 1ST STAGE HOPPER TO ADULT, IN THE YEAR 1952.

Abbreviations:—I, NYMPHS ISOLATED IN TUBES; G, NYMPHS IN GENERAL CAGE

Date of hatching (1952)	1st stage	Period	2nd stage	Period	3rd stage	Period	4th stage	Period	5th stage	Period	6th stage	Period	7th stage (adult)	Total Period (in days)
30th April , (G) (Both sexes)	30-4-52 to 11-5-52 12-5-52	12-13 days	11-5-52 12-5-52 to 24-5-52 25-5-52	About 13 days	24-5-52 25-5-52 to 6-6-52 8-6-52	13-15 days	6-6-52 8-6-52 to 18-6-52 26-6-52	About 12 days	18-6-52 20-6-52 to 1-7-52 3-7-52	13-16 days	1-7-52 3-7-52 to 18-7-52 20-7-52	About 18 days	18-7-52 to 20-7-52	80-87
3rd May , (G) (Both sexes)	3-5-52 to 13-5-52 16-5-52	10-13 days	13-5-52 16-5-32 to 26-5-52 29-5-52	13-18 days	26-5-52 29-5-52 to 9-6-52 12-6-52	About 14 days	9-6-52 12-6-52 to 23-6-52 26-6-52	About 12 days	23-6-52 26-6-52 to 7-7-52 8-7-52	About 14 days	7-7-52 8-7-52 to 24-7-52 26-7-52	About 18 days	24-7-52 to 26-7-52	81-91
30th April (I) male & female (2)	30-4-52 to 11-5-52	12 days	11-5-52 to 24-5-52	13 days	24-5-52 to 6-6-52	13 days	6-6-52 to 18-6-52	12 days	18-6-52 to 1-7-52	13 days	1-7-52 to 19-7-52	18 days	19-7-52	81
3rd May (I) female (1)	3-5-52 to 15-5-52	12 days	15-5-52 to 27-5-52	12 days	27-5-52 to 12-6-52	16 days	12-6-52 to 26-6-52	14 days	26-6-52 to 10-7-52	14 days	10-7-52 to 28-7-52	18 days	28-7-52	86
,, ,, ,, female (1)	3-5-52 to 16-5-52	13 days	16-5-52 to 26-5-52	10 days	26-5-52 to 10-6-52	15 days	10-6-52 to 22-6-52	12 days	22-6-52 to 6-7-52	14 days	6-7-52 to 25-7-52	19 days	25-7-52	83

TABLE VII. LIFE-CYCLE OF 4 PAIRS OF INDIVIDUALS OF *Aularches punctatus* DRURY IN THE INSECTARY AT NEW FOREST, DEHRA DUN.
(FROM TABLES 2, 3 AND 5)

Pair	Sex	Length of period					Number of egg-ponds laid	Number of eggs in consecutive egg-pods
		Hatching to Eclosion. (Days)	Eclosion to copulation (Days)	Copulation to oviposition. (Days)	Eclosion to death. (Days)	Total (Days)		
A	Male Famale	80 80	7 8	— 10	48 50	128 130	— 3	120,90,81=291
B	Male Female	82 83	8 7	— 11	28 40	110 123	— 2	100,92=192
C	Male Female	84 86	8 8	— 9	46 59	130 145	— 3	108,92,78=278
D	Male Female	80 81	11 11	— 15	29 54	109 135	— 2	118,98=216
	Range of male	80-84	7-11	—	29-48	109-130	—	Average of 1st laying—111.5 ,, of 2nd ,, —93 ,, of 3rd ,, —79.5 ,, of all ,, —98
	Average of male	81.5	8.5	—	37.8	119.2	—	
	Range of female	80-86	7-11	10-15	40-59	123-145	2-3	
	Average of female	82.5	8.5	11.3	50.8	133.2	2	

PECULIAR MODE OF LOW TEMPERATURE-QUIESCENCE IN THE SHORT-HORNED GRASSHOPPER, *CHROTOGONUS CONCARUS* KIRBY (ORTHOPTERA: ACRIDIDAE)

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(With 1 plate and 2 tables)

I. OBSERVATIONS

During a study of the ecology of the Indian Acrididae, I observed both the sexes of *Chrotogonus concarus* Kirby digging the soil simultaneously with their hind-legs instead of with the genitalia as females do for oviposition. Later on, many individuals were observed to "hibernate" under soil. The details are described below:—

In the early part of November, 1953, at Dehra Dun, U. P., (altitude *Ca.* 2000 ft. above sea-level) a large number of adults and nymphs of *Chrotogonus concarus* were collected in the New Forest area; a few adults were also collected from the banks of the river Tons near Dehra Dun. All these were caged in a big glass trough with about 9 inches of sandy-loam at the bottom; they were fed on green grass.

For further observations, they were segregated in pairs, each pair being kept in a small glass jar, with an 8-inch layer of sandy-loam. A temperature record of the Insectary room was taken twice a day; the average monthly temperatures are given in Table I. Air temperatures inside the trough, the jars and in the open ground outside the Insectary were recorded as follows (Table II):—(1) 8-10 inches above the soil; (ii) 0.5-1.0 inch below the soil; and (iii) 5-6 inches below the soil.

TABLE I. Average monthly temperature in Insectary at New Forest, Dehra Dun, in 1953-1954, during (and immediately preceding and following) months when low temperature-quiescence in *Chrotogonus concarus* Kirby occurred.

Months	Year	Average monthly air temperature in Insectary in °C.	
		9. A. M.	4.30 P. M.
September	1953	25.0	27·61
October	1953	19.3	23.1
November	1953	14.3	18.2
December	1953	12.5	16.7
January	1954	9.4	12.7
February	1954	13.2	17.5

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*Government of India's Senior Research Scholar.

It was noticed that as soon as the temperature of the air fell to 10° C. or below, the hoppers as well as adults started digging the soil with the simultaneous movements of their hind-legs. When small, shallow pits had been dug, the individuals tried to fit themselves into them. If they failed to secure a good fit, they came out again until the pits were of a suitable size to accommodate them fully. Having established themselves suitably into the pits, they bring their hind-legs parallel to the abdomen and keep them in that position. Then, first they cover abdomen with the soil by means of their middle-legs till the wings and the abdomen are fully covered. Their bodies have also been noticed to make slight movements in order to provide complete packing of the soil on the sides. Later, the head and thorax are similarly covered with the soil by means of the fore-legs. Only the antennae and the eyes are left exposed. This feature was observed both in the field as well as in the Insectary cages. Such individuals as had failed to secure shelter in the soil either clasped each other irrespective of the sex or died of the severe cold with their limbs stretched. This was observed only in the field.

With a rise in temperature above 10° C. the insects were observed creeping out of their burrows. If there was no rise in temperature, the quiescence under the soil may last as long as 4-7 days and sometimes even a fortnight. In December, 1953, and January, 1954, rains were unusually continuous. As a result, the temperature went down to 6° C and the individuals already under the soil were noticed burying themselves deeper. Their eyes, and in a few cases even their antennae, were no longer visible on the surface. Four of these individuals under observations were found at a depth of 2-6 inches below soil surface. Of these, two were dead; and the other two became active again when kept in the bright sun for an hour.

II. Discussion

Since the temperature below the soil is higher than the temperature of the air (Table II), a few species of short-horned grasshoppers have been observed undergoing quiescence below the soil when the temperature of the air was below 10° C.

Uvarov (1928) observed hibernation only in the hoppers of *Pyrgomorpha conica* Olivier. The hoppers and adults of *Chrotogonus concarus*, discussed here, resemble the adults of *Acrotylus insubricus* Scop. (Nikolsky, 1925), also burying under soil below 10° C. but coming out as the temperature rises. Joyce (1952) reported the survival of the adults of the Pyrgomorphinae under bark and in cracks during winter. *Chrotogonus concarus*, however, differs in undergoing quiescence only up to about a fortnight at Dehra Dun, whereas, in *Acrotylus insubicus* it is prolonged throughout the winter in Turkistan. The Pyrgomorphinae of Sudan survive under bark and in cracks, whereas adults and hoppers of *Chrotogonus concarus* were seen seeking shelter under the hay in the field near the bank of the river Tons and also under the soil as described above.

TABLE II. Temperature records below and above the soil in cages and outside the Insectary, New Forest, Dehra Dun, on dates at the time (during the day between 9 A. M.—5 P. M.) when the digging-in of *Chrotogonus concarus* Kirby actually occurred.

Note:— In each case the temperature was taken in 4 or 5 places within a few inches of the vertical line where the insect was boring, and averaged.

Dates (1954 Jan. & Feb.)	Temperature on dates when low temperature quiescence was observed			
	Inside cages and jars in the Insectary			Outside the Insectary, near (outdoor) cages.
	Average air temperature in C°., 8-10 inches above the soil.	Average temperature in C°., 0.5-1.0 inch below the soil.	Average temperature in C°, 5-6 inches below the soil.	Average air temperature in C°., 8-10 inches above the ground soil.
2-1-54	7.3	7.3	9.6	7.5
4-1-54	8.2	8.4	9.0	8.5
5-1-54	8.8	9.1	9.4	9.4
11-1-54	8.1	6.0	8.3	8.0
12-1-54	8.4	6.0	8.8	8.9
13-1-54	8.7	7.3	9.7	9.0
14-1-54	8.7	8.2	10.2	9.0
15-1-54	8.3	7.5	9.5	8.9
16-1-54	8.4	7.9	9.8	8.9
20-1-54	8.8	8.6	9.7	10.0
21-1-54	8.7	8.7	10.5	9.0
22-1-54	6.1	5.9	8.6	6.0
23-1-54	7.2	5.5	8.8	7.0
25-1-54	7.1	8.5	9.2	9.5
27-1-54	8.9	8.6	9.8	9.8
28-1-54	9.2	8.7	9.8	10.1
29-1-54	9.4	7.6	9.2	9.8
1-2-54	10.0	10.5	11.8	10.8

III. SUMMARY

When the air temperature falls to 10° C or below, the hoppers and adults of *Chrotogonus concarus* dig shallow pits in the soil and bury themselves into it for warmth. They may so remain in the quiescence state for as long as a fortnight. Individuals which could not get shelter were seen clasping other individuals; and some die of the cold with their limbs stretched.

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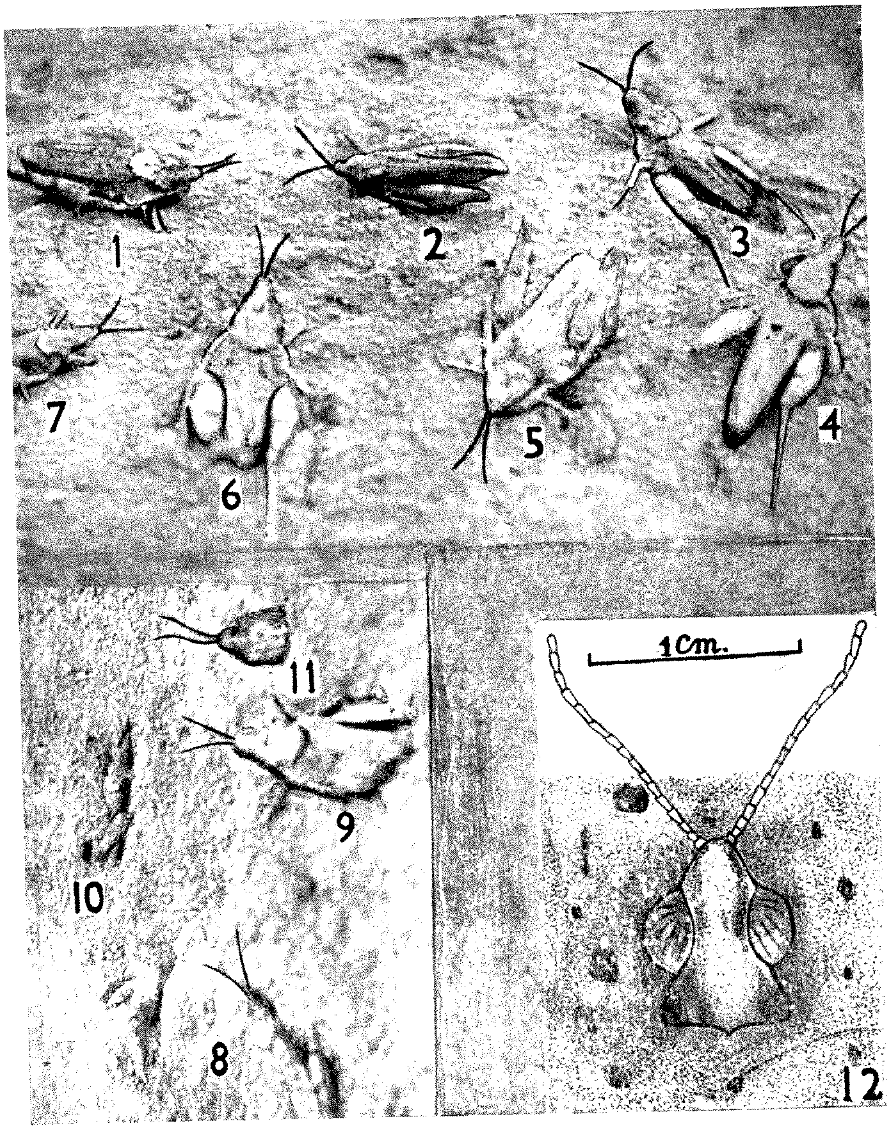

Figs. 1-7. Individuals preparing for quiescence.

Figs. 8-10. Individuals partly gone under soil.

Fig. 11. Individual has completely gone under the soil; only the antennae and the head remain out.

Fig. 12. A completely buried individual; only the head and antennae are out. Enlarged.

NEUROSECRETORY CELLS IN INSECTS

By K. K. Nayar, *Dept. of Zoology, University College, Trivandrum.*

Introduction

The discovery of the presence of neurosecretory cells in the central nervous system of various animals, both vertebrate and invertebrate, was made by Ernst and Berta Scharrer in 1928. Neurons with nissl bodies, neurofibrils, dendrites and axons, were seen to show cytological characteristics of glandular activity in certain regions. This suggested a neuroglandular structure and the cells came to be known as neurosecretory cells. The cytoplasmic structures which represented the glandular products in the form of granules and droplets could be stained in a variety of ways. Scharrer (20.21,22), Stutinsky and others (14) showed that the chrome alum-haematoxylin-phloxin method of Gomori (12) gives a selective staining of these cells and their products. In certain cases at least, equally good results have been obtained by using Heidenhain's Azan method, Masson's trichrome stain and Gomori's aldehyde-fuchsin method.

Berta Scharrer has shown the presence of neurosecretory cells in the central nervous system of Annelida, Arthropoda and Mollusca among invertebrates. A review of the occurrence and significance of these cells has been recently given by Ernst and Berta Scharrer (23,24).

Among Arthropoda, insects have been investigated by a number of workers. Weyer (30) first described the presence of these cells in insects in the brain of the honey bee. Scharrer (19) described them in the cockroaches; Dupont-Raabe (8,9) in phasmids; Arvy and Gabe (1,2) in Ephemerida and Odonata; Hanstrom (13) and Nayar (16) in Hemiptera; Arvy and Gabe (3) in Plecoptera; Williams (32), Arvy, Bounhiol and Gabe and others in Lepidoptera; De Lerma (1954) Arvy and Gabe in Coleoptera; M. Thomsen (28), E. Thomsen (25), Possompes (18), and Nayar (17) in Diptera and M. Thomsen (29) in Hymenoptera.

Distribution

Neurosecretory cells in the central nervous system of insects are located as given below:

Situated in the brain is a pair of closely placed cell clusters forming the median cerebral neurosecretory cells (Figs. 1, 2). These are situated in the central part of the lobed cerebral ganglia in the region called the pars intercerebralis. Besides these central clusters, there are a few laterally placed cells commonly designated as the lateral cerebral neurosecretory cells. The neurosecretory cells of the pars intercerebralis are generally present in all groups of pterygote insects.

In the suboesophageal ganglion are some neurosecretory cells which do not however form composite structures as in the case of the cerebral cells. In the cockroaches these form conspicuous neurosecretory cells.

The thoracic and abdominal ganglia also contain neurosecretory cells (Fig. 3). Such cells are also seen in the ganglia of the sympathetic system.

In the apterygote insects the cerebral median cells are collected into an encapsulated organ which however remains connected with the brain (14).

HISTOLOGY AND STRUCTURE

Histological and cytological details observed after chemical treatments and staining have fully supported the view that these cells are glandular neurons. The neuronal nature of these cells is proved by their location in the central nervous system, structural details and development. Besides fixed and treated cells, those in living condition also have been studied under the ordinary, phase-contrast and dark ground microscopes. Under the phase-contrast microscope, these cells show a highly granulated cytoplasm composed of two distinct types of structures viz. finely granular bodies and a system of fine spheroids of variable sizes (17). Large, vacuole-like drops are conspicuous. The nuclei are large, rounded, with low refractive index, while the nucleoli have a higher refractive index. The dark ground pictures show that the cells contain a conspicuous mass of granules and fine droplets of a bluish-white colour which flow along the axons (Thomsen 26).

The neurosecretory cells are selectively stained by chrome alum-haematoxylin-phloxin in a number of insects. The general effect produced by this stain is a deep blue colouration of the cytoplasmic products. The axons of these cells contain blue granules which are the colloids flowing out along them from the cell-body. This led authors to designate the neurosecretory cells as Gomori-positive because of the blue colouration by chrome-haematoxylin. But recent workers have shown that these cells do not stain as reported above, in all insects; further, it has also been shown that the tintorial properties vary according to the state of activity of these cells in the same animal.

The exact nature and cytochemistry of the products of the neurosecretory cells are not definitely known.

FUNCTIONS

The discovery of the neurosecretory cells initiated a series of experimental investigations. Of the centres of neurosecretion in insects, only the functional significance of the cerebral median cells is well known.

The classic experiments of Wigglesworth (review by Bodenstein, 5) revealed the endocrinological basis of insect metamorphosis. He showed that the brain is the controlling element in the activity of the endocrine organs like the thoracic glands, corpora allata etc. The hormonal basis of insectan development and growth has been later proved beyond doubt by other workers. The brain activates the thoracic glands which bring about moulting and growth in insects. The metabolic processes in growth and juvenile nature of the larval stages are controlled by the hormones coming from the corpora allata. Wigglesworth (31) presumes that the activity of the corpus allatum also is dependent on the brain.

It is believed that the thoracic gland is activated by the cerebral median neurosecretory cells and that these centres also activate the corpus allatum. Scharrer (23) suggests that they produce the prothoracotropic hormone and the allatotropic hormone. Cytological evidence of the supply of the neurosecretory material to the corpus allatum in the silkworm has been given by Bounhiol, Gabe and Arvy (6).

Experimental studies by Scharrer (21,22) reveal that the products from the neurosecretory cells accumulate in the corpora cardiaca by way of the nerves that arise from the brain and supply these glands. In the cockroach *Leucophaea maderae*, she cut on one side the nerve connections and demonstrated that the secretion accumulates in the corpus cardiacum and shows the characteristic colouration on the side where the nerve is intact, while in the transected side the secretory accumulation was wanting. Thomsen (27) tied the nerve of the adult *Calliphora erythrocephala* with a fine silken thread. This resulted in a blocking of the flow of secretory material in the axons of the cerebral neurosecretory cells which form the cardiac recurrent nerve supplying the corpus cardiacum. Proximal to the ligature secretory material accumulated which conclusively proves that the neurosecretory products from the cerebral cells travel along their axons to the corpus cardiacum. The corpus cardiacum is a storage organ and is probably merely a reservoir, or might store and elaborate fresh secretions either activated by this secretion or mixed with it.

Thomsen's earlier work (21,22) shows that reproduction in the female blowflies is controlled by the median cerebral neurosecretory cells. She also points out that protein synthesis in the body is to certain extent controlled by these cells. She concludes that the median neurosecretory cells of the brain must be regarded as the overall controlling centre of the endocrine system.

In certain insects like the silkworms there is the phenomenon of arrestation of development and growth known as diapause. This occurs in egg, larval or pupal stage. The pupal diapause in *Platysamia cecropia* was studied by Williams who shows that the neurosecretory cells of the brain by their activity terminates diapause (Williams 1952). According to Fukuda (10) a principle originating in the suboesophageal ganglion of the silkworms determines the production of diapause-eggs. He (10 a, 1) shows that voltinism in the silkworm is due to this hormone.

Evidence has been brought forward to show the existence of a myotropic principle produced in the neurosecretory cells which influence peristalsis of the malpighian tubules (24).

In the words of Hanstrom (15) "the neurosecretory cells of the insect brain are directly or indirectly connected with the regulation of heart activity, moulting, growth, sexual maturity, metabolism, water balance, and probably also with physiological colour change."

I am indebted to my colleague Mr. R. P. Pillai, for help in photography.

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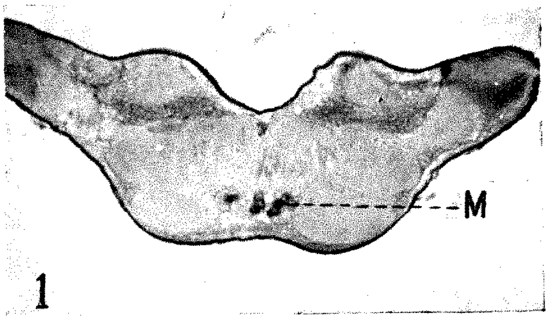
Plate XVI

Fig. 1. Transverse section passing through the brain of *Iphita limbata* Stal. Bouin fixation; Gomori's chrome haematoxylin phloxin. Approx. × 50. The neurosecretory cells are seen in the middle of the brain.

Fig. 2. Sagittal section of the nerve ring of *Iphita limbata* Stal. Bouin fixation; Gomori's chrome haematoxylin phloxin. × 75.

Fig. 3. Horizontal section of the metathoracic ganglion of *Iphita limbata* Stal. Bouin fixation; Gomori's chrome haematoxylin: × 75 Approx.

Index to lettering M: median neurosecretory cells of brain.
O: oesophagus.
S: suboesophageal ganglion
T: neurosecretory cells of the thoracic ganglia.



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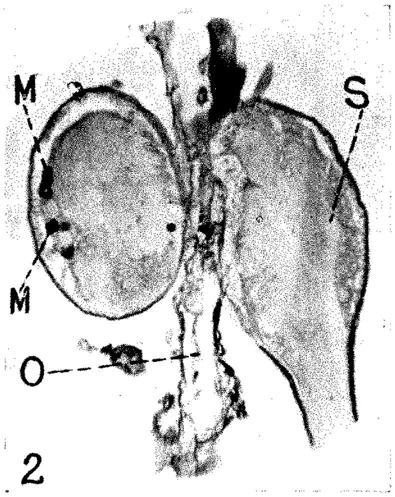

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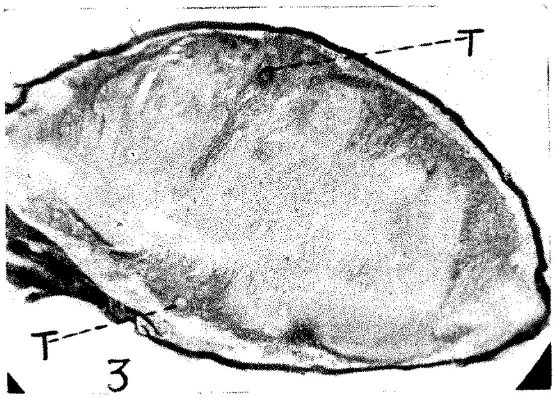

3

NOTES ON SOME INDIAN DERMAPTERA

By T. N. Ananthkrishnan B. Sc. (Hons.) F. Z. S., F. R. E. S. and B.N. Ramamurthi, *Zoology Laboratory, Loyola College, Madras*-6.

The diversity of structure of the male genitalia of earwigs has considerable taxonomic significance. The early attempts of Zacher (1911)* and by Burr (1911, 1915 & 16)* remain practically the only works of importance. The nature of the genitalia in a good number of species has yet to be described and on the basis of the genital structure, a revision of the genera and species seems imminent. In this connection Hincks (1951, 52, 53, and 54,) has attempted redescription and revision of some of the genera and species, mostly European, laying special stress on the genitalia.

Though the genitalia of a few species of Labiduridae, mostly belonging to the carcinophorinae, were studied by Burr (1915 & 16), it is by no means complete. The authors, on the basis of a series of fine mounts of the genitalia, have attempted to describe the genitalia of *Labidura riparia* Pallas, *Nala lividipes* Dufour, *Forcipula quadrispinosa* Dohrn and *Euborellia annulipes* Lucas. The word parameres in the accompanying description refers to the freely projecting metaparameres.

The authors wish to express their thanks to Dr. W. D. Hincks of the Manchester Museum for kindly determining the specimens sent to him and for the literature provided.

LABIDURIDAE

Labidurinae

Forcipula quadrispinosa Dohrn

The Parameres (fig. 1) are acuminate, their margins almost straight; midrib well defined, rather chitinous. Between the two parameres a wide space occupied by the right forwardly directed penis lobe virga. The reflexed penis lobe on the left is exactly of the same size and proportion. Parameres 0.784 mm long and 0.168 mm wide at middle. Preputial sac, 0.91 mm long, devoid of chitinous plates, broad at base, slightly narrowing distad, where it is again a little dilated. The inflated basal vesicle of Zacher oval, 0.168 mm long and 0.056 mm wide. The spiral winding is continued also at the base of the vesicle into a narrow tube, ending abruptly. Virga very long, ramifying throughout the

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*Zacher—1911. Zool. Jahrb. Abt. Syst. 30.
Burr—1911. Trans. Ent. Soc. London.
Burr—1915, 1916—Jour. Roy. Micr. Soc,

preputial sac, 0.910 mm long and 0.084 mm wide at middle, and extends much farther beyond where it becomes narrow. Epimerites 0.084 mm long, well developed and digit-like; not acutely pointed distad.

Nala lividipes Dufour

Parameres 0.476 mm long and 0.112 mm wide at middle, acuminate, distally very much narrowed, epimerites absent, midrib strongly developed; chitinisation of paramere margin very feeble, except for a small strip at outer margin close to hinge. Preputial sac 0.700 mm long, 0.070 mm wide at middle, 'ink -filler' like, narrow and tubular distally. Inflated vesicle, 0.168 mm long, 0.056 mm wide at middle, plano-convex, with outer margin straight as in fig. 2 Virga strongly developed, convoluted even inside preputial sac.

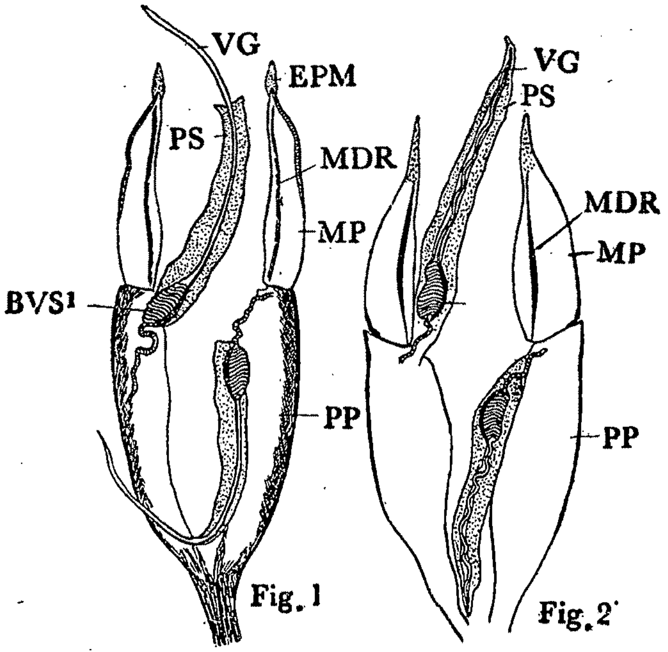

FIG. 1. *Forcipula quadrispinosa* Dohrn

FIG. 2. *Nala lividipes* Dufour BVS and BVS^1 basal vesicle, EPM epimerite, MDR midrib, MP metaparamere, PP proparamere, PS preputial sac, VG virga.

Labidura riparia Pallas

Parameres 0.534 mm long, 0.154 mm wide at middle, acuminate, distally curved and hooked at tips (fig. 3). Chitinisation of margins feeble; midrib feebly chitinised, epimerites small, digitate, preputial sac thin and membranous. Vesicle 0.154 mm long and 0.084 mm wide at middle.

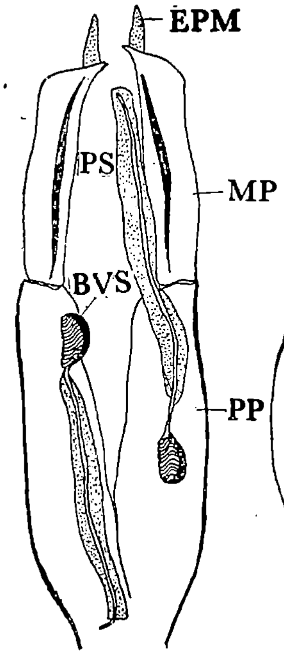

Fig. 3

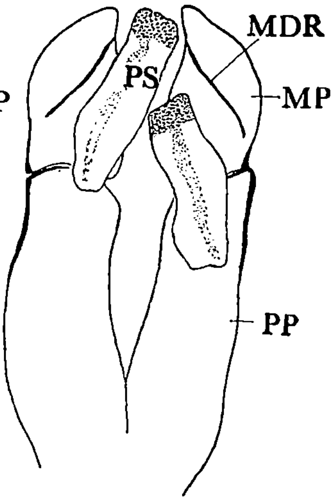

Fig. 4

FIG. 3. *Labidura riparia* Pallas

FIG. 4. *Euborellia annulipes* Lucas BVS and BVS^1 basal vesicle, EPM epimerite, MDR midrib, MP metaparamere, PP proparamere, PS preputial sac, VG virga.

SUBFAMILY Carcinophorinae

Euborellia annulipes Lucas

The parameres are characteristic of the genus, being broad and expanded with the apices of the preputial sac bearing numerous chitinous denticles as in fig. 4. Parameres about 0.350 mm. long and 0.266 mm. wide at middle.

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MORPHOLOGY OF THE PADDY GALL MIDGE *PACHYDIPLOSIS ORYZAE* MANI (ITONIDIDAE=CECIDOMYIIDAE : DIPTERA).*

By SANTOKH SINGH, M. Sc., *Research Associate* and Miss S. K. MISRA, M. Sc., *Former Post-graduate Student, School of Entomology, St. John's College, Agra.*

I. INTRODUCTION

This paper summarizes the results of our studies on the general morphology of *Pachydiplosis oryzae* Mani. This is the first attempt made in India to study in some detail the structure of any adult gall-midge. We give here brief accounts of external features, skeletal muscles, alimentary canal, nervous and reproductory systems. The tracheal system has not been studied.

We take this opportunity of expressing our grateful thanks to Prof. Dr. M. S. Mani, Professor of Zoology and Entomology, School of Entomology, St. John's College, Agra, for guidance and facilities for work.

II. PREVIOUS WORK

Gall midges have attracted the attention of biologists from very early times. They have been extensively studied in Europe and America. In India the study of these insects has been very much neglected. Our knowledge of the Indian Gall midges is derived largely from the works of Kieffer (21,22), Y. R. Rao (55-58), Felt (8-13), Mani (24-38), and in recent years Nayar (42-45) and S. N. Rao (49-54). While the taxonomy of the gall midges has greatly advanced in the hands of Rübsaamen, Kieffer, Felt, Mani and others, morphological studies have been very much neglected. Rübsaamen (59) contributed to our knowledge of the morphology of the gall midge larva. Giard (16) was one of the first to describe the sternal spatula and malpighian tubules of the larvae. Williams (65) has given an excellent account of the anatomy of the larva of *Cecidomyia resinicoloides*. Wehrmeister (63) made a special study of the alimentary canal of the midge larva. In 1931 Haseman (17) described the anatomy of the larva of *Mayetiola destructor* (Say). Miss Margot Metcalfe (40,41) studied the anatomy of the larva of *Dasyneura leguminicola* Lint., especially of the female genital system. Sen (62) published an account of the anatomy of the full grown larva of *Rhabdophaga saliciperda* Dufour. In the same year Otter (46, 47) dealt with the comparative morphology of the larvae of *Lestodiplosis miki* Barnes, *Clinodiplosis cilicrus* Kieff., and *Dasyneura miki* Kieff. White (64) carried out detailed cytological investigations on the chromosomes and determination of sex in gall midges. Comparatively little has, however, been done with regard to the morphology of the adult gall midge. Rübsaamen's (60) account is very sketchy and deals with only the external morphology. Couderc (6) recently published a brief account of the anatomy of the adult of *Perissia affinis* (Kieff.) from Europe. The only other work of importance is that of Miss Anderson (1, 2) on the morphology of the larva and adults of *Oligotrophus oleariae* Mask. and *Dryomyia shawiae* Anders. from New Zealand. The other works of importance are cited in the Bibliography at the end.

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*Contribution No. 60 from the School of Entomology, published with the permission of the Professor of Zoology and Entomology.

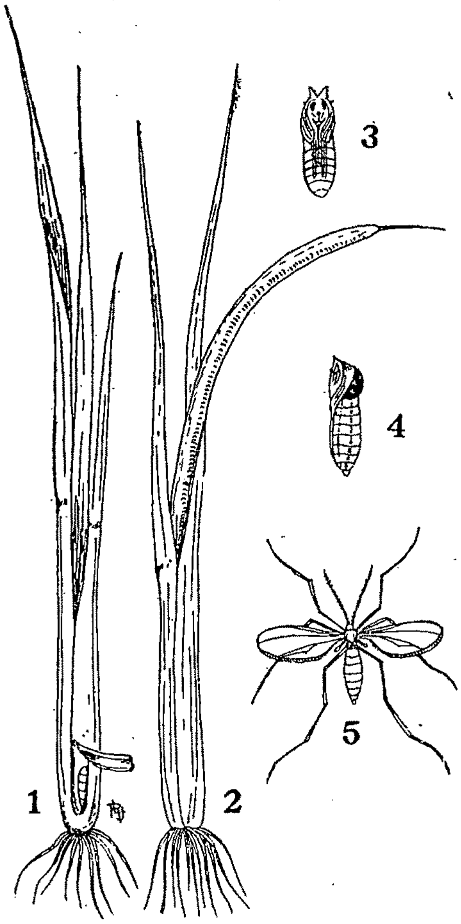
III. MATERIAL AND METHOD

Over five thousand specimens were collected by light trap from paddy fields in Saurashtra. They were fixed in rectified spirit and preserved in the same to which a few drops of glycerine were added. Dissections were carried out under the Stereoscopic binocular microscope in the usual way. The internal organs were dehydrated, cleared and imbedded in paraffin in the usual way. Both sagittal and transverse sections, 6μ thick were cut. The sections were stained either with acid fuchsin or Mallory's triple stain; haematoxylin and eosin. Whole mounts of various parts were also made. All sketches were made with the help of Camera lucida.

IV. BIONOMICS

The paddy gall midge, *Pachydiplosis oryzae* Mani, occurs in India, Ceylon, Burma, Siam, Indo-China, Formosa, Malaya, Philippines, Sumatra and Java. It was first observed in 1880 in Monghyr district, Bihar. Wood-Masson (66) in 1881 mentioned it under the name *Cecidomyia oryzae* and in 1921 Felt (10) referred to the genus *Pachydiplosis* Kieffer. The species was, however, first described in 1934 only by Mani (25). It belongs to the tribe Trifilini of the subfamily Itonididinae and is distinguished from the two other related species viz. *P. ceylonicus* (Kieff.) and *P. graminicola* (Kieff.) by the different proportions of antennal, palpal and other characters (25).

While the adult midges are short lived and do not feed, the larvae undergo a prolonged development inside the tender, hollow, long, tubular gall on the rice plant. The gall caused by this midge is popularly called "Silver-shoot disease," "anakomban," "elephant tusk" or "gangai disease." The gall formation involves the growing tip of the rice plant (fig. 2). The adult female midge deposits its eggs on the underside of the tender leaf. The eggs are glued to the leaf surface by a secretion of the accessory glands. At first the eggs are light pink but soon turn darker. The young larvae hatch in about five days. The larvae migrate down to the leaf base and bore into the stem (fig. 1) and reach the growing tip. In the place of the normal ear, the silvery-white, tubular gall develops. The larvae become full grown in about a week and pupate in the gall. The early pupae (figs. 3 & 4) lie at the bottom of the tubular gall cavity, but



FIGURES 1-5

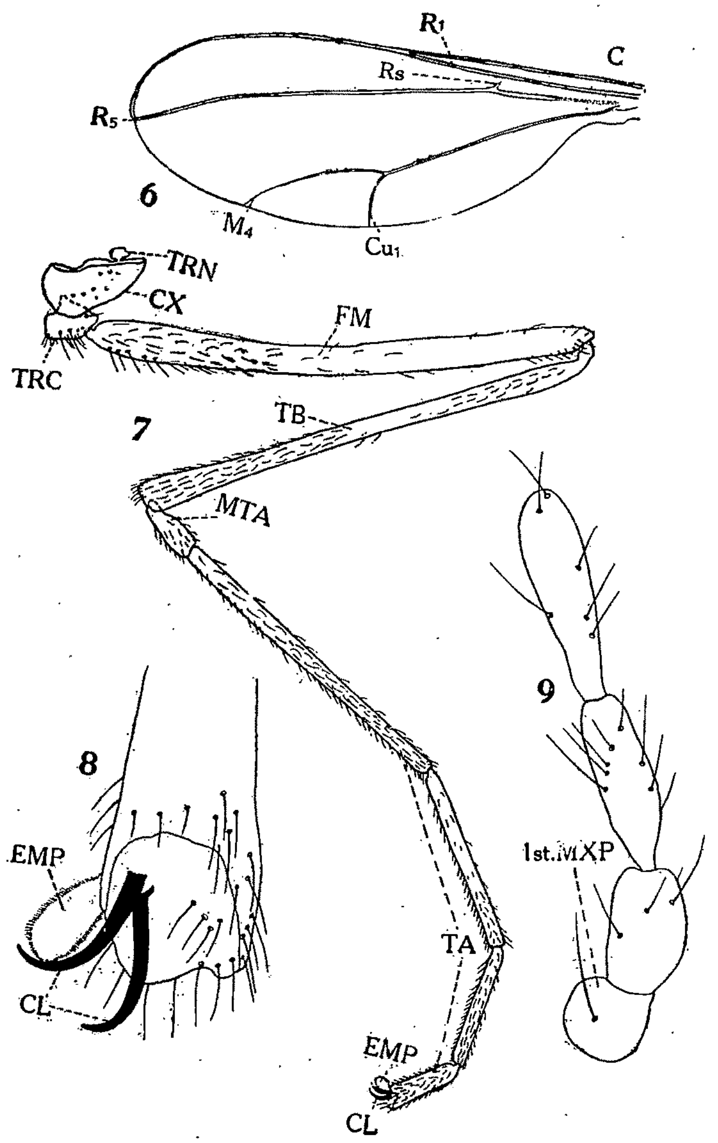
1 A rice plant showing the larva in situ.
2. A rice plant with terminal shoot formed into a gall.
3. Pupa seen from front.
4. Side view of pupa.
5. Adult *Pachydiplosis oryzae* Mani.

before emergence of the adult, wriggle up to its apex. Pupal period lasts for about a week. The adults emerge during the night. The total life-cycle lasts for about 20 days.

V. EXTERNAL MORPHOLOGY

The body of the adult of *Pachydiplosis oryzae* Mani (fig. 5) is, like that of other gall midges, delicate, soft and comprises three more or less distinctly segmented regions, viz. the head, the thorax and the abdomen. The head bears a pair of elongate, slender antennae, large compound eyes and greatly reduced mouthparts. Ocelli are absent.

The thorax is largely taken up by the greatly enlarged, arched and complex mesothorax; the pro- and meta-thorax being very much reduced. The thorax bears a pair of large wings, three pairs of long, slender legs and a pair of halteres. The coxae are short and the tibiae lack spurs. The abdomen is



FIGURES 6-9

6. Wing, 7. Leg, 8. Enlarged view of the pretarsus, 9. Maxillary palp.

C. costa; *Cl.* claw; Cu_1 cubitus vein;
Cx. coxa; *EMP.* empodium; *FM*, femur;
M_4. medius 4; *MTA.* metatarsus; R_1 Radius;
R_5. radius 5; *Rs.* Radial sector;
TA. Tarsi. *TB.* tibia; *TRC.* trochanter;
TRN. trochantin; *1st. MXP.* first segment of the maxillary palp.

composed of variable number of distinct segments and bears the ovipositor or the male genital claspers apically. The body is moderately densely clothed with setae. Scales and bristles are absent.

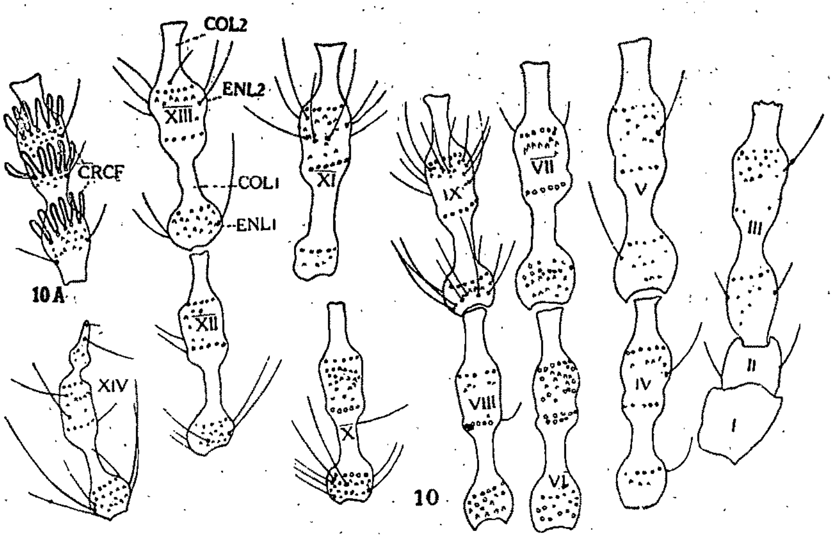
There is pronounced dimorphism between the sexes. The adult female is relatively large, the length varying from 3.5 mm to 4 mm. It is also somewhat stouter, especially in the abdomen. The general colour of the body is bright reddish-brown. The antennae are moderately densely setose, dark brown and about half the length of the body. The flagellate antennal segments are cylindrical, though somewhat constricted about the middle. The abdomen is stout and bears apically the somewhat exserted short ovipositor. The male is distinctly smaller and its length never exceeds 3.0 mm. It is more sombre coloured, yellowish-brown, sparsely setose and with the abdomen setose. The antennae are relatively more densely setose, reddish-brown and nearly as long as the body. The flagellate antennal segments are all binodose, with three conspicuous whorls of circumfila. The tip of abdomen bears the conspicuous brown genital claspers.

In both male and female, the wings are neither too long nor too broad; hyaline, densely clothed with marginal and discal dark setae. When at rest, the wings are kept flat over the dorsum of abdomen, one wing overlapping the other. The legs all touch the ground and are held close to the surface on which the midge is resting.

Head

The head is moderately large, lenticular, black or very dark-brown and freely movably articulated with the thorax by means of narrow, slender, cervix (fig. 12, CERV.). Viewed in front, the head is circular in outline. It is somewhat flattened antero-posteriorly. Most of the visible surface of the head is occupied by the very dark reddish-brown, moderately shortly setose, holoptic compound eyes. The dorsal eye bridge is broad. In anterior view the compound eye presents the appearence of a horse-shoe-shaped mass on the head. The ommatidia are small and circular. The narrow space between individual ommatidia bears soft, short, slender setae. The face is somewhat convex and the occiput is almost flattened. The occiput bears long conspicuous curved setae behind the eyes. The face shows a conspicuous longitudinal sutural line extending from in between the antennal sockets down to nearly half the head where it bifurcates into two short arms. The part of the face immediately above the mouth is somewhat bulging forwards and represents the narrow and elongate clypeus, which bears a conspicuous tuft of elongate setae.

The Antennae.—The antennae are inserted in the middle of the face, close to each other and above the bifurcation of the sutural line described above. In both the sexes the antenna is composed of 14 segments (figs. 10, 11). The first segment or the scape is short, stout, irregularly subglobose or obconical, and thicker apically than basally. The second segment or pedicel is somewhat shorter, globose and slightly more slender. The scape and pedicel are sparsely setose. The remaining 12 antennal segments, which constitute the flagellate segments, differ essentially from scape and pedicel and also exhibit pronounced sexual dimorphism. In both male and female the third and fourth antennal (i. e. 1st & 2nd. flag.) are fused together. The flagellate segments are elongate cylindrical in female and binodose in male. The cylindrical flagellate segments of the female are slightly constricted about the middle and reduced into slender and short stem apically. The circumfila are low and comprise an apical and a basal girdle connected together by a longitudinal filum. In addition to the close, short surface pubescence, the enlargements of the flagellate segements bear a basal and an apical whorl of very long, stout setae.



FIGURES 10-10 A.

10.I—XIV segments of the male antenna.
10 A. Detailed structure of the typical male antennal segment.
COL 1. basal stem; *COL*2. apical stem;
CRCF. circumfila; *ENL*1. first enlargement; *ENL*2. second enlargement.

In the male the binodose flagellate segments have each a subglobose short basal enlargement and a subcylindrical longer but often constricted apical enlargement. The basal stem between the basal and apical enlargements is usually stouter than the apical stem. The basal enlargement bears in addition to the short surface pubescence, one basal whorl of long setae and a subapical whorl of moderately long loops of circumfila (fig. 10 A). On the apical enlargements there are two whorls of long setae and two whorls of circumfila loops. The flagellate segments become gradually thinner and longer apically. The constriction about the middle of the apical enlargements also become somewhat more and more pronounced apically, so that the terminal flagellate segments exhibit a tendency towards the trinodose condition. The fourteenth antennal segment of both male and female has a conspicuous elongate pyriform prolongation (figs. 9, 10). The proportions of the enlargements and stems of different flagellar segments are of considerable taxonomic importance and are described by Mani (25).

The Mouthparts

The adult being relatively-short-lived and non-feeding, the mouthparts are extremely reduced, vestigial and non-functional for ingestion of food. They merely appear to serve as sensory organs in the selection of the suitable host plant for the egg laying. As in other related members of the Bibionoidea, the mandibles and hypopharynx are absent. The labrum is represented by a narrow, short subtriangular piece, immediately beneath the clypeus. The transverse line described by Couderc (6) as dividing the labrum into a short basal transverse and an apical more elongate portion in *Perissia affinis* (Kieff.) cannot be seen in this midge. In certain species like *Oligotrophus oleariae* Mask. the labrum-epipharynx is elongate and triangular (Anderson, 1). Behind the labrum epipharynx, on either side are greatly reduced maxillae. Kellog (19) does not describe the maxillary lobes and Anderson (*loc. cit.*) describes only the galea. In *Pachydiplosis oryzae* Mani, we may however observe on each side a reduced but distinct basal unsegmented part (representing the undifferentiated cardo-stipes) bearing the palpi and an apical simple, short, vestigial, emarginate, subtriangular galea, which bears sensory setae apically. The basal part of maxilla has a conspicuous globose palpiger from which arises the quadriarticulate palpi. There seems to be considerable confusion in literature regarding the true nature of the palpi of gall midges. While some workers like Rübsaamen (60), Anderson (1, 2)

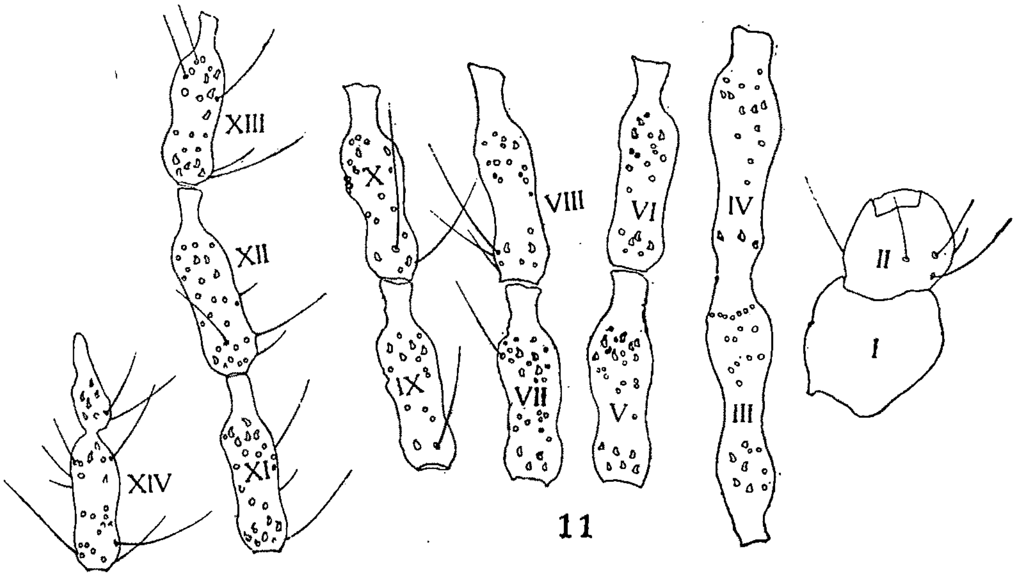


FIGURE 11.

I-XIV. segments of the female antenna.

(1, 2) consider them to represent the maxillary palpi, Couderc (6) has described these structures in *Perissia affinis* as labial palpi. Couderc's figures leave, however, little doubt regarding the maxillary origin of the gall midge palpi. The palpi of *Pachydiplosis oryzae* are short, slender, pale brown structures. The relative proportions of the palpal segments are described by Mani (25) and have great taxonomic value. The first segment is the shortest (fig.9, 1st. MXP.) and the fourth is the longest. The labium is also much reduced and is represented by a narrow transverse piece behind and shorter than the maxillae. The so called ligula of Couderc (6) and the labella or biarticulate labial palpi described by Rübsaamen in *Aprionus bidentatus* Kieff. are not present in *Pachydiplosis oryzae* Mani. The hypopharynx is believed by Frey (15) to be wholly fused with the labium in *Rhabdophaga salicis* but free according to Becher (3). In *Pachydiplosis oryzae*, as already mentioned, there is however no trace of the hypopharynx.

The Thorax

The thorax (fig. 12) has a complex structure and exhibits profound modifications of the general pattern. It consists almost entirely of the

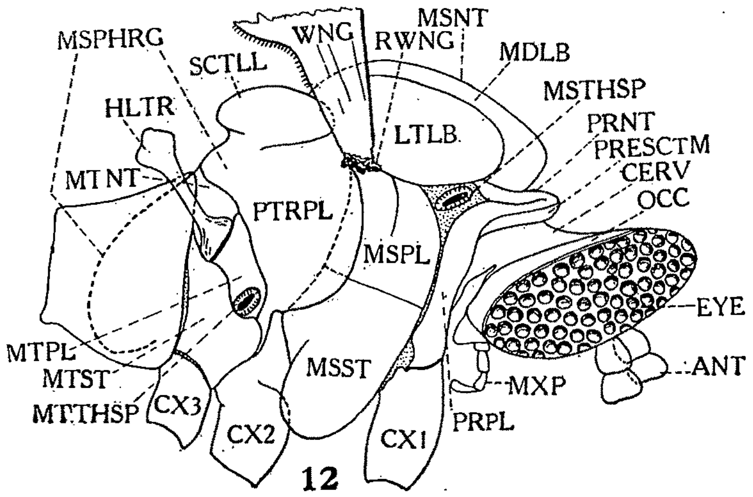


FIGURE 12. Sclerites of the thorax.

ANT. antenna; *CER.* cervix; *CX1.* fore coxa;
CX2. mid coxa; *CX3.* hind coxa; *EYE.* eye;
HLTR. haltere; *LTLB.* lateral lobe;
MDLB. middle lobe; *MSNT.* mesonotum;
MSPHRG. mesophragma; *MSPL.* mesopleura;
MSST. pre-episternum of the mesothorax;
MSTHSP. mesothoracic spiracle; *MTNT.* metanotum;
MTPL. Metapleura; *MTST.* pre-episternum of the metathorax; *MTTHSP.* metathoracic spiracle;
MXP. maxillary palp; *OCC.* Occiput; *PRESCTM.* prescutum of the prothorax;
PRNT. pronotum;
PRPL. propleura; *PTRPL.* pteropleura;
RWNG. root of the wing; *SCTLL.* scutellum;
WNG. wing.

pterothorax, the prothorax being greatly reduced and the metathorax almost vestigial. As a result of the very pronounced shifting forwards of the dorso-ventral axis of the mesothorax, the extremely narrow prothorax has come to be almost concealed beneath the conspicuously arched anterior part of the mesothorax. The visible dorsum of the thorax is thus largely composed of the greatly convex mesonotum (MSNT). The arching of the mesonotum and the concealing of the prothorax antero-ventrally beneath the mesothorax has not however reached the extreme condition we find in certain other gall midge genera like *Hormomyia*. The propleura (PRPL) is a narrow lateral piece above the fore coxa (CXI) and also has a short slender cervical sclerite (CERV) in front. The mesonotum (MSNT) is divided into a median (MDLB) and two lateral parts (LTLB) by a pair of conspicuous submedian lines, bearing a row of long, black setae. Behind the mesonotum (MSNT) lies a short transverse, rather pronouncedly convex scutellum (SCTLL). The metanotum (MTNT) is very narrow and hardly sclerotized and is almost completly concealed beneath the first abdominal tergite. The mesophragma (MSPHRG) is conspicuously strongly sclerotized and also greatly enlarged posteriorly and ventrally and projects into the cavity of the first abdominal segment, which it nearly fills up. The side of the thorax is composed of the mesopleura (MSPL) in front, the extensive pteropleura (PTRPL) behind directly below the attachment of the wings (WNG) and a narrow and short metapleura (MTPL) below the halteres (HLTR). The heavily sclerotized and conspicuous socalled mesosternum of authors does not represent the sternum of the mesothorax (Ferris, 14) but is evidently the pre-episternum (MSST) described by Champu (4) in *Chauliognathus pennsylvanicus* and by O. N. Saxena (61) in *Mylbaris pustulata.* Next to the mesonotum (MSNT), the pre-episternum (MSST) is the largest and the most conspicuous of the sclerotized externally visible parts of the thorax. It separates the fore and mid legs by a slight gap. It is distinctly marked off above by a transverse suture from the mesopleura (MSPL). The pre-episternum of the metathorax (MTST) is short and lies below and behind the metaplura (MTPL); it is the so called metasternum of the authors. There are two pairs of large spiracles on the thorax. The first pair of spiracles has been described by all workers and lies in the membranous side below the antero-lateral angle of the mesonotum. Although it really represents the mesothoracic spiracle (MSTHSP), it has however been quite erroneously labelled by Rübsaamen (60), Couderc (6), Anderson (1,2) and others as prothoracic spiracle. The second spiracle, which was first observed by Marchel (39) and is labelled by Rübsaamen (60) and others as the mesothoracic spiracle is in fact the metathoracic spiracle (MTTHSP) and situated below the root of the halteres (HLTR). It is slightly smaller than the first spiracle.

Wings.—The wings (fig. 6) are large, thin, membranous, hyaline, nearly thrice as long as broad. Each wing is clothed by long, dark discal setae and marginal fringe, especially on the hind margin. The venation, as in other gall midges, is greatly reduced and comprises the costa, which continues round beyond the wing apex, but is interrupted at its union with R_5; the second vein is the short R_1; the third vein of earlier workers is R_5

and in the posterior region are the forks of veins M_4 and Cu_1. The socalled cross-vein or the radius sector (Rs) is extremely faint and unpigmented. The nomenclature of the veins is taken from Mani (34) and from the recent work by Hening (18). In the terminology of the earlier workers these veins are called the costa, subcosta, cubital and postical veins (Couderc, 6). The vein R_5 reaches costa at apex of wing. The socalled fourth vein of Kieffer is absent.

Halteres.—The halteres (fig. 12, HLTR) are conspicuous, long, moderately stout and knobbed, with broad bases. They are reddish-brown in the female and brown in the male.

Legs.—The legs are long (fig. 7), slender, densely setose and brown. Each leg comprises a short, stout coxa and a short inconspicuous trochanter. The femur is slender and exceedingly long, several times longer than thick and dark brown. The tibia is slender and nearly as long as the femur as already mentioned and lacks spurs. The tarsus is five-segmented and more than one and a half times the length of tibia. As in the rest of the Itonididinae the first tarsal segment or metatarsus is exceedingly short. The second tarsal segment is the longest and is about three-fourths the tibia. The third tarsal segment is a little more than half the second and the fourth segment is about three-fourths the third. The terminal tarsal segment is shorter, about half the length of the third, but somewhat longer than the metatarsus. The claws are small, slender, evenly curved, simple, neither furcate nor dentate. The empodium is well developed and somewhat shorter than the claw. Pulvilli are absent (fig. 8).

Abdomen

The abdomen exhibits pronounced sexual differences. In the male it is slender, flattened dorso-ventrally and brown. In the female it is bright red, rather stout, broad, greatly distended with eggs, not much flattened above. There are eight visible segments in the female, the remaining terminal segments being greatly modified and telescoped into the eighth segment. The abdominal tergites and sternites are moderately broad, but not heavily sclerotized. In the pleural membranous folds are concealed the eight minute abdominal spiracles. In the male only seven segments are visible. The anus is terminal and dorsal to the genital aperture, which is situated between the ninth and tenth sternites. The ovipositor and male genitalia, borne at the tip of abdomen, are described under section dealing with the reproductive system of organs.

VI. SKELETAL MUSCLES

The skeletal muscles comprise chiefly the muscles of the thorax, legs and abdomen. The muscles of the antenna may also be included here. The musculature of the male genitalia is dealt with under the section of reproductive organs.

Musculature of Head

The musculature of the head is greatly reduced owing to the non-functional mouthparts. It includes pharyngeal dilators (to be described later), the labral muscles (fig. 21, LBRM), labial (LBM) and the antennal muscles.

Muscles of Antenna.—There are two extrinsic and three instrinsic muscles of the antenna.

Extrinsic Antennal Muscles.—i. Antennal depressor (Fig. 19, ANTDP) and ii. Antennal levator (fig. 19, ANTLR), both weak and arising on a slender tentorial arm and inserted below and above respectively on base of scape.

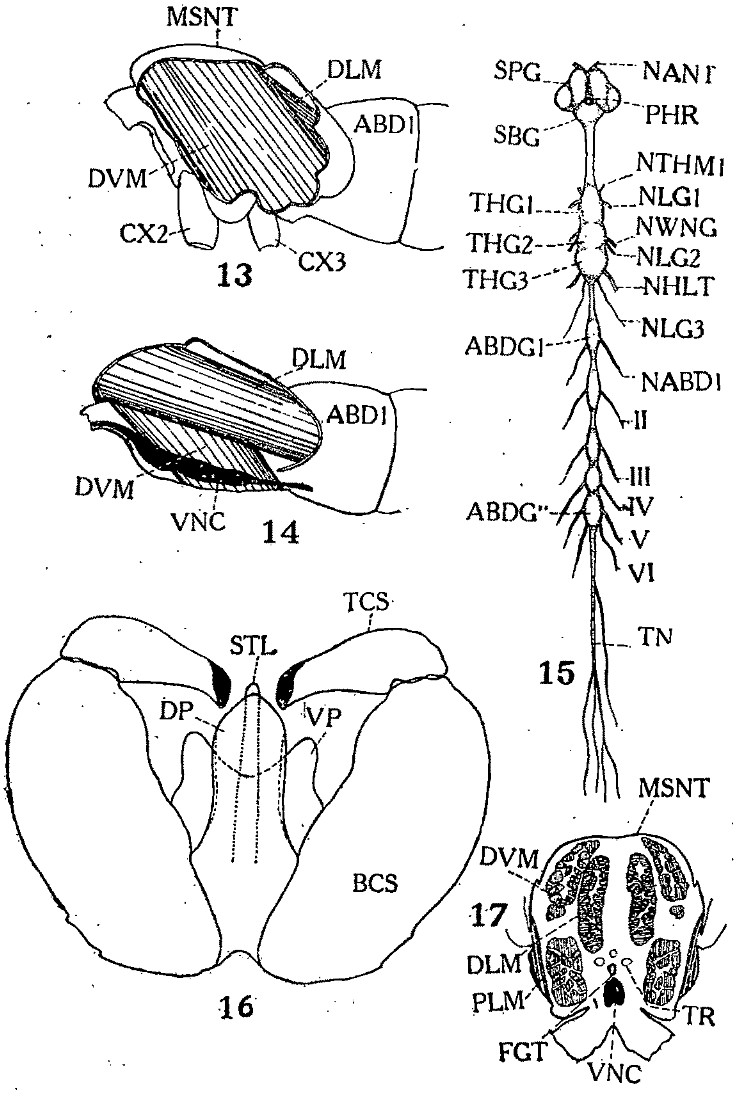
Intrinsic Antennal Muscles.—i. Flexor (fig. 19 ANTFL), ii. Extensor (fig. 19, ANTEX) of antenna arising mesially and laterally respectively near base within scape and inserted basally in pedicel messially and laterally; iii. Antennal rotators (fig. 19, ANTR) arising within the pedicel and inserted in base of first flagellar segment.

Musculature of Thorax

The musculature of thorax is on the whole the best developed in the midge. With the reduction of the prothorax and metathorax, their muscles have also nearly disappeared, except for the reduced extrinsic leg muscles. The muscles of the pterothorax on the other hand are well developed but are also considerably modified. These comprise the longitudinal, ptergosternal and pleural muscles, in addition to the muscles of the mid leg.

i. Dorsal Longitudinal Muscles.—(figs. 13, 14 & 17 ; DLM). These are conspicuous, stout paired bundles, extending obliquely posteriorly from the inside of the greatly arched anteromedian part of the mesonotum down deep into the first abdominal segment to be attached on the anterior face of the enormously enlarged mesophragma. These muscle bundles occupy a great part of the thoracic cavity. Anderson (1) has described five bundles of the dorsal longitudinal muscles in *Oligotrophus oleariae* Mask. In *Pachydiplosis oryzae* there are however many more and smaller bundles on each side. The two dorsal longitudinal muscles are attached to the inner surface of the mesonotum on the mesial sides of the submedian lines. The contraction of these powerful muscles arches up the pteronotum. Though strictly longitudinal in the generalized insects like grasshoppers, in the gall midge these muscles slope obliquely behind and almost appear to be oblique dorso-ventral muscles. This is due to the enormous enlargement and shifting of the mesophragma downwards and behind underneath the slender metanotum as already described.

ii. Dorsoventral Muscles.—(figs. 13, 14, & 17; DVM) The dorsoventral muscles of each side lie lateral to the dorsal longitudinal muscles. They are two groups of stout bundles on either side, stretching from mesonotum down largely to pre-episternum and partly to base of the mid-coxa. One of these bundles passes through coxa to its insertion on base of trochanter. The attachment of



FIGURES 13-17.

13. lateral view of the thorax showing dorso-ventral muscles. 14. lateral view of the thorax showing dorsal longitudinal muscles.
15. nervous system. 16. male genitalia.
17. T. S. through the mesothorax.

*ABD*1. first abdominal segment; *ABDG*1. first abdominal ganglia; *ABDG.* fifth abdominal composite ganglia; *BCS.* basal clasp segment;

*CX*2. mid coxa; *CX*3. hind coxa; *DLM.* dorsal longitudinal muscles; *DP.* dorsal plate.

DVM. dorso-ventral muscles; *FGT.* foregut;
MSNT. mesonotum; *NABD I*, II, III, IV, V, VI. abdominal nerves; *NAT.* antennal nerve;
NHLT. nerve to haltere; *NLG*1, *NLG*2, *NLG*3. nerves to the first, second and third legs;
*NTHM*1. nerve to the muscles of the prothorax and oblique muscles; *NWNG.* Nerve to the wings;
PHR. aperture for the oesophagus; *PLM.* pleural muscles; *SBG.* suboesophageal ganglia; *SPG.* supra oesophageal ganglia; *STL.* style;
TCS. terminal clasp segment; THG_1, THG_2,
*THG*3. pro, meso-, and metathoracic ganglia. *TM.* terminal nerve; *TR.* trachea;
VNC. ventral nerve cord; *VP* ventral plate;

these muscles on the inner surface of the mesonotum (MSNT) is on the part outside of the submedian lines. The dorsoventral muscles (DVM) are not strictly dorsoventral but like the dorsolongitudinal muscles, are to a considerable extent oblique, so that their attachment to the mesonotum is conspicuously anterior to that on the pre-episternum below. It is thus apparent that profound modifications and shifting of the axis lines have occurred in the musculature of the thorax of gall midges.

iii. Pleural Muscles.—The pleural muscles (fig. 17, PLM) are rather small, weak bundles. Three of these bundles lie on the dorsoventral muscles and represent part of the pleural muscles of the generalised pterothorax.

Musculature of Leg

All the typical muscles of the generalized insect leg are found in this midge. The muscles of the midleg may be considered as typical (fig. 18). They comprise the extrinsic muscles, which move the leg as a whole and the intrinsic muscles within the leg. Part of the bundles of the dorsoventral muscles which are inserted on the base of coxae (not shown in figure) and on the base of trochanter and extend above upto the mesonotum act as the extrinsic leg muscles. These are relatively weak bundles. The intrinsic muscles of the leg include the levator of trochantero-femur (TRCL), which act as the antagonist of the bundle of dorsoventral muscles (TRCDPR) inserted in the apodeme in trochanter. The flexor (TVDPR) and extensor (TBL) of tibia arise in the femur, a small bundle of flexor muscles arise also in the trochanter and are inserted at base of tibia. The flexor of pretarsus (PTRDPR) arises by a series of bundles in the femur and tibia and the fibres are inserted on a long common tendon passing through femur, tibia and tarsus to end in the unguitractor plate. The trochanteral rotator of femur arises in the trochanter and is inserted in femur (FMRD). The tarsal extensor (TRL) and flexor (TRDPR) arise in the latter half of the tibia and are inserted at the base of metatarsus.

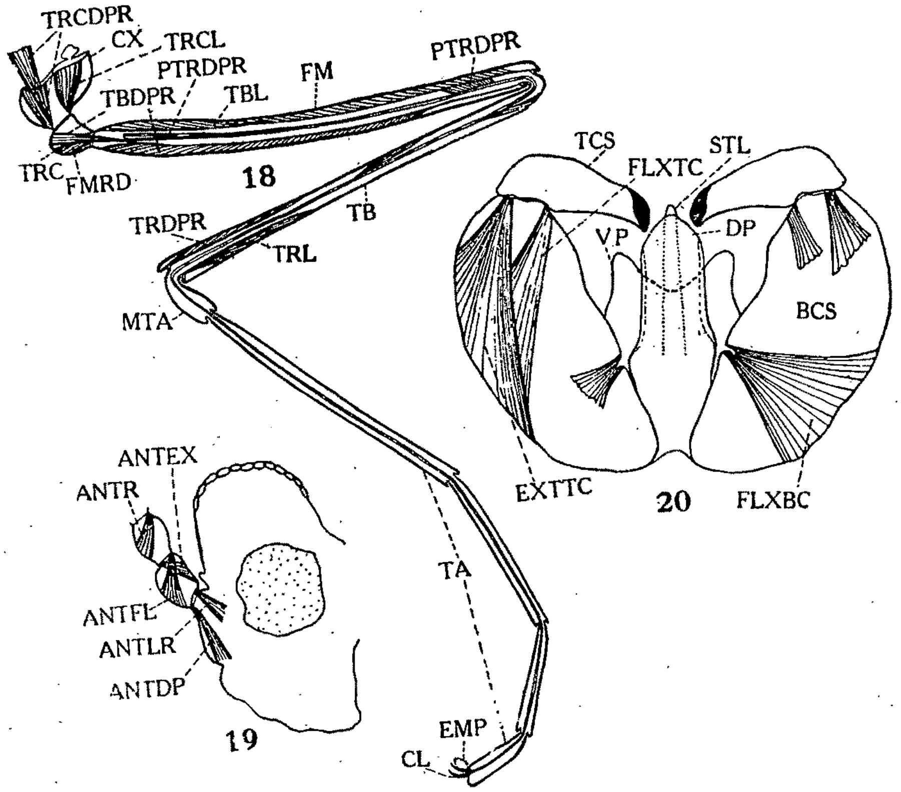
Musculature of Abdomen

The typical dorsal and ventral longitudinal, dorsoventral and pleural muscles of the abdominal segments of the generalized insect are present, but nearly all muscles are greatly weakened. The musculature of the genitalia is dealt with under reproductive organs.

VII. Alimentary Canal

Fore gut

Correlated undoubtedly with the non-feeding habit of the relatively



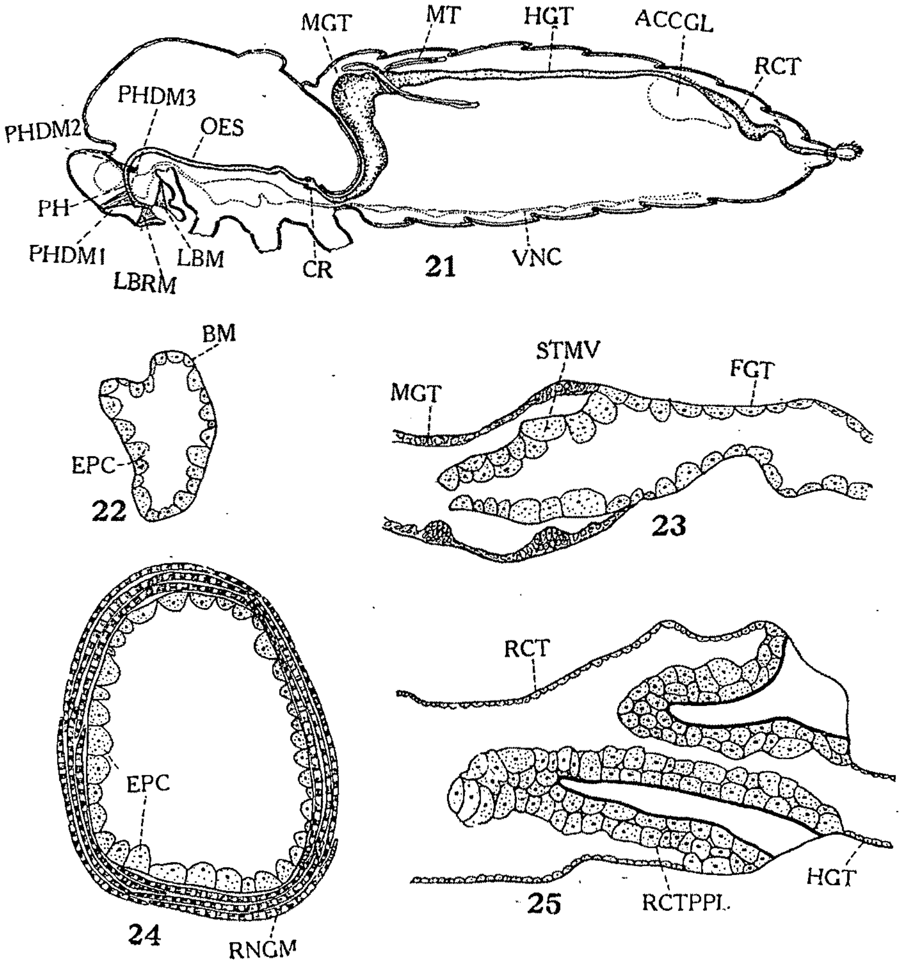
Figures 18-20.

18. Musculature of leg. 19. Antennal muscles. 20. Musculature of male genitalia.
ANTDP. antennal depressor; *ANTEX.* antennal extensor; *ANTFL.* antennal flexor;
ANTLR. antennal levator; *ANTR.* antennal rotator; *BCS.* basal clasp segment;
CL. claw; *CX.* coxa; *DP.* dorsal plate;
EMP. empodium; *EXTTC.* extensor of the terminal clasp segment; *FLXBC.* flexor of the basal clasp segment; *FLXTC.* flexor of the terminal clasp segment; *FM.* femur;
FMRD. trochanteral rotator of the femur;
MTA. metatarsus; *PTRDPR.* flexor of pretarsus;
STL. style; *TA.* tarsi; *TB.* tibia; *TBDPR.* flexor of tibia; *TBL.* extensor of tibia;
TCS. terminal clasp segment; *TRC.* trochanter;
TRCDPR. bundles of the dorso-ventral muscles;
TRCL. levator of the trochantero-femur;
TRDPR. tarsal flexor; *TRL.* tarsal extensor;
VP. ventral plate.

short lived adult, the alimentary canal is reduced to a mere vestige. It is nevertheless complete and all the essential parts of the alimentary canal of a generalized insect may be recognized in a more or less greatly degenerate state (fig. 21). The mouth, which is moderately sunk within the head, opens into a slender, Y-shaped and nearly collapsed pharynx (fig. 26, PHR). The intima is relatively thick, so that the pharynx almost appears to be a wholly chitinous tube. The pharyngeal dilator muscles (fig. 21; PHDM1, PHDM2 PHDM3), which we see in other insects are present here also, but are represented by extremely thin and weak bundles. Two of these stretch from the cranial wall to the front of the pharynx, in front of the brain. There are smaller bundles of muscles likewise behind the brain. A pair of greatly reduced lateral dilator muscles are also present. The pharynx passes behind as an extremely slender tube through a fine aperture in the ganglionic complex of the head and enters the cervix anb passes into the oesophagus (fig. 21, OES). In the thorax the oesophagus is to a certain length nearly as slender as the pharynx. The intima however is not so thick in the oesophagus as in the pharynx and is also nearly smooth. The epithelial cells are relatively large and have also conspicuous nuclei (fig. 22). The oesophageal epithelium is not however, thrown into longitudinal folds, so characteristic of the foregut in feeding insects. Somewhat further behind, the oesophagus becomes distinctly dilated. In the male this dilation is more pronounced than in the female. The cells in this enlarged portion are inconspicuous, rather flattened and have smaller nuclei. This enlargement passes imperceptibly into the rather degenerated crop (fig. 21, CR). which is quite similar in minute structure to the posterior dilated end of oesophagus. The posterior end of crop narrows down into the cardiac valve (fig. 23, STMV). A somewhat similar cardiac valve is described in adult of *Oligotrophus oleariae* by Anderson (1), who did not, however, find it well developed in the adult of *Dryomyia* (2.) This part therefore, appears to present different degrees of degeneration in different species of midges. The epithelium of the cardiac valve is composed of large cells with conspicuous nuclei. The muscular coat of fore gut (FGT) is nearly obsolete.

Mid gut

The mid gut (fig. 23, MGT) commences in the posterior part of the thorax immediately behind the cardiac valve. Though relatively the largest part of the entire alimentary canal, it is greatly degenerate and often found collapsed and disintegrated. It passes behind underneath and to one side (fig. 27, MGT) of the mesophragma (MSPHRG), to the posterior (upper) surface of which it lies close in the first abdominal segment, where it turns abruptly upwards to one side and also becomes somewhat dilated (fig. 21, MGT). It is further displaced by the numerous ova, with which the abdomen is replete (fig. 31). In the abdomen the mid gut lies dorsally above the mass of ova. The wall of the mid gut is extremely simple, with a few small flat cells containing conspicuous nuclei. The muscular coat is absent. Anderson (1) mentions the midgut of *Oligotrophus oleariae* as filled with a yellowish liquid, but in the preserved material of *Pachydiplosis oryzae* it is not possible to describe the nature of the midgut contents. In most specimens studied the mid gut was generally



FIGURES 21-25.

21. Alimentary canal. 22. T. S. fore gut.
23. Sagittal Section of the stomodeal valve. 24. T. S. rectum. 25. L. S. rectum showing rectal papillae.

ACCGL. accessory gland; *BM.* basement membrane; *CR.* crop; *EPC.* epithelial cells;
FGT. fore gut; *HGT.* hind gut;
LBM. labial muscle; *LBRM.* labral muscles;
MGT. mid gut; *MT.* malpighian tubules;
OES. oesophagus; *PH.* pharynx; *PHDM1*, *PHDM2*, *PHDM3.* pharyngeal dilator muscles;
RCT. rectum; *RCTPPL.* rectal papillae;
RNGM. ring muscles of the rectum;
STMV. stomodeal valve; *VNC.* ventral nerve cord.

found burst and almost crushed out of shape and place both by the mesophragma and by the enormous mass of eggs inside the abdomen.

Hind gut

Towards the posterior part of the first abdominal segment, the mid gut passes into the hind gut (fig. 21, HGT). Like the mid gut, the hind gut is also wholly dorsal in the abdomen. The hind gut is longer than the mid gut and perhaps also less conspicuously degenerated. This part of the hind gut is a slender tube, with relatively stout wall, in which the circular muscles are distinct. After a short course it enlarges somewhat and becomes thin walled. Posteriorly of this dilation lies the stout rectum with rather thick walls (fig. 24, RNGM). In the female, the rectum lies in between and is greatly crushed by the enormous accessory glands (fig. 29, ACCGL). The rectum narrows down behind and extends backwards dorsal of the vagina (fig. 28. RCT & VAG). It terminates in a minute anus (fig. 34, ANUS) posteriorly in the tenth segment, in between and above the lamellae (fig. 34, LM) of the ovipositor (fig. 34) and is thus dorsal to the female genital aperture (fig. 34, GOP). Couderc (6) however describes the anus as situated ventrally in the seventh abdominal segment in the adult female of *Perissia affinis*. In the anterior part of the rectum there are semi conspicuous rectal papillae (fig. 25, RCTPPL) which are very distinctly seen both in sagittal and transverse sections of the rectum. These extend as slender tubes from the wall of the gut distally free in the lumen of the rectum. The cells that compose these tubes are relatively large and have prominent nuclei. Anderson does not describe the existence of such rectal structures in the two species of midges studied by her.

Malpighian tubules.—There are two well developed, moderately long somewhat stout and looped malpighian tubules (fig. 21, MT). The loops often extend as far behind as the anterior end of the accessory glands in the female. A part of the loop is also directed anteriorly over the posterior end of the mid gut in the first abdominal segment. Externally it is not always quite simple matter to distinguish the malpighian tubules from the slender hind gut itself, but in sections the typical structure of the malpighian tubules is quite unmistakable (figs. 29, 30, MT). Their lumen often contains minute crystals also.

Salivary Glands.—Although well developed and often large salivary glands are known to be present in the larvae of gall midges (Couderc, Sen, etc), the existence of these structures in the adult gall midge does not seem to have been so far demonstrated. In some specimens of adult *Pachydiplosis* an occasional vestige of the salivary gland cells in the thorax indicates the almost complete state of degeneration of these organs.

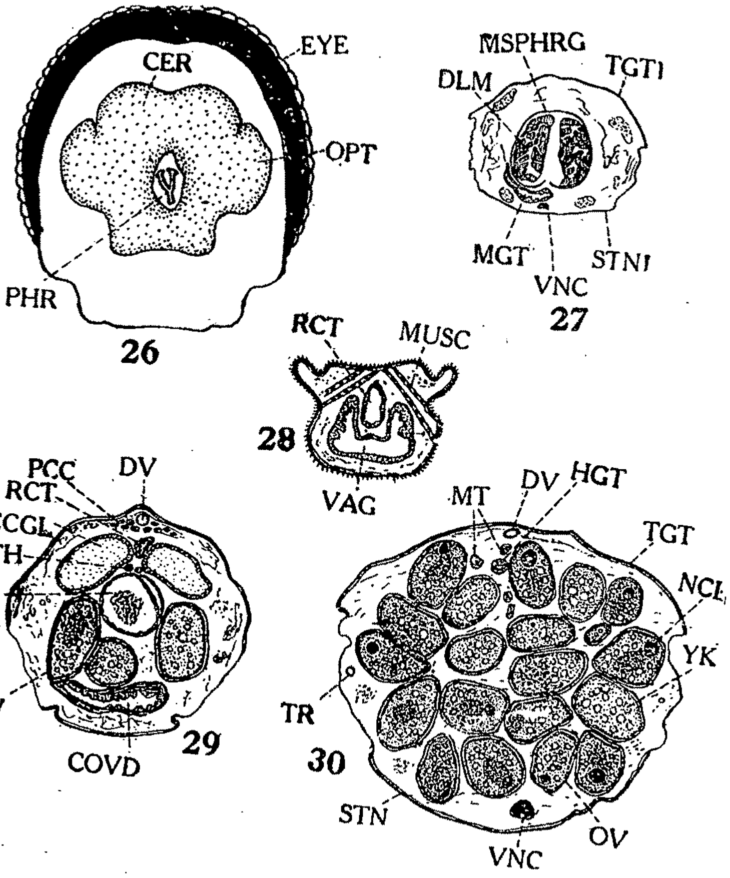
VIII. DORSAL BLOOD VESSEL

A delicate and slender dorsal blood vessel, (figs, 29, 30, DV) extends from about the eighth abdominal tergite to nearly the first. Minute masses of

Pericardial cells (fig. 29, PCC) and an extremely delicate dorsal diaphragm are also seen. The blood vessel does not seem to extend into the thorax.

IX. Nervous System

The nervous system is characterized by considerable approximation and consolidation of ganglia, especially in the thorax (fig. 15). Cephalic part of



FIGURES 26-30.

26. T. S. through head. 27. T. S. through first abdominal segment. 28. T. S. through last abdominal segment. 29. T. S. through eighth abdominal segment. 30. T. S. through middle of the abdomen.

ACCGL. accessory glands; *CER.* cerebral lobe; *COVD.* common oviduct; *DLM.* dorsal longitudinal muscles; *DSPTH.* duct of the spermatheca; *DV.* dorsal blood vessel; *EYE.* eye *HGT.* hind gut; *MGT.* mid gut; *MSPHRG.* mesophragma; *MT.* malpighian tubules; *MUSC.* muscles of the last abdominal segment; *NCL.* nucleus of the ova; *OPT.* optic lobe; *OV.* ova; *PCC.* pericardial cells; *PHR.* pharonx; *RCT.* rectum; *SPTH.* spermathecae; *STN.* sternite; *STNI.* sternite of the first abdominal segment; *TGT.* tergite; *TGT1.* tergite of the first abdominal segment; *TR.* trachea; *VAG.* vagina; *VNC.* ventral nerve cord; *YK.* yolk.

the system represents certain interesting features in association with the holoptic condition of the compound eyes. There is also considerable reduction in the nerves in the head. . .

The brain or the supra-oesophageal ganglionic mass (SPG) is a large, compound structure, with faint indications of lobes as in figure. On either side it is connected with the conspicuous and enormously enlarged optic lobes (fig. 26, OPT). A pair of moderately stout antennal nerves (fig. 15, NANT) arises from the supra-oesophageal complex. The circum-oesophageal commissures are short and rather very stout, so that the supra-oesophageal and sub-oesophageal (SBG) ganglionic masses appear as a single complex structure, merely pierced by a minute aperture for the passage of the pharynx (PHR) . The nerves from the sub-oesophageal mass are degenerate and extremely slender and comprise a pair to the maxillae and a fine pair to the labium. The ventral nerve cords behind the sub-oesophageal ganglia are short and stout. The three thoracic ganglia (fig. 15, THG1, THG2, & THG3) are fused together to a composite mass in the pterothorax. Obscure constrictions in this composite mass indicate the limits of the three component ganglionic parts. The prothoracic and the mesothoracic parts are almost of the same size but the metathoracic part is distinctly larger. The prothoracic part of the ganglionic complex gives off two nerves. The first (NTHM 1) of these nerves arises dorso-laterally in front and innervates muscles of the anterior body wall and parts of the oblique muscles. The second nerve is given off slightly posterior to and ventral of the first and enters the fore leg (NLG1). Similarly from the mesothoracic part of the ganglionic mass a set of nerves is given off. The first pair (NWNG) arises dorsally and turns upwards through the oblique muscles and controls the wing movements. The second pair supplies the middle legs (NLG2). The metathoracic part of the ganglionic complex supplies nerves to the halteres (NHLT) and to the third leg (NLG3). The second set of nerves originates posterior and ventral to the first one.

Behind the metathoracic part of ganglionic complex, the narrow ganglionated ventral nerve cord continues in the abdomen. In the first five segments of the abdomen there are five distinct and separate pairs of ganglia (ABDG1-ABDG"). Each of these ganglia give off a pair of nerves in each segment except the fifth pair, (NABD1, 2, 3, 4, 5, 6). The fifth pair of ganglia gives off two pairs of nerves, the second pair entering the sixth abdominal segment. Posteriorly the fifth abdominal ganglia continues as a slender unganglionated terminal nerve (TN). From this cord very slender nerves supply the remaining abdominal segments and the genitalia.

Anderson (1) has described all the abdominal ganglia as fused into a single mass in *Oligotrophus oleariae* Mask. From this composite mass, she records only four nerves which supply to the first five abdominal segments. Other nerves for the remaining segments and for the genitalia arise from the unganglionated terminal part of the ventral nerve cord. The same author (2) has described in *Dryomyia shawiae* Anders. that there are only three abdominal ganglia. In *Pachydiplosis oryzae* Mani, however, the abdominal part of the central nervous system largely retains its generalized condition.

X. REPRODUCTIVE SYSTEM

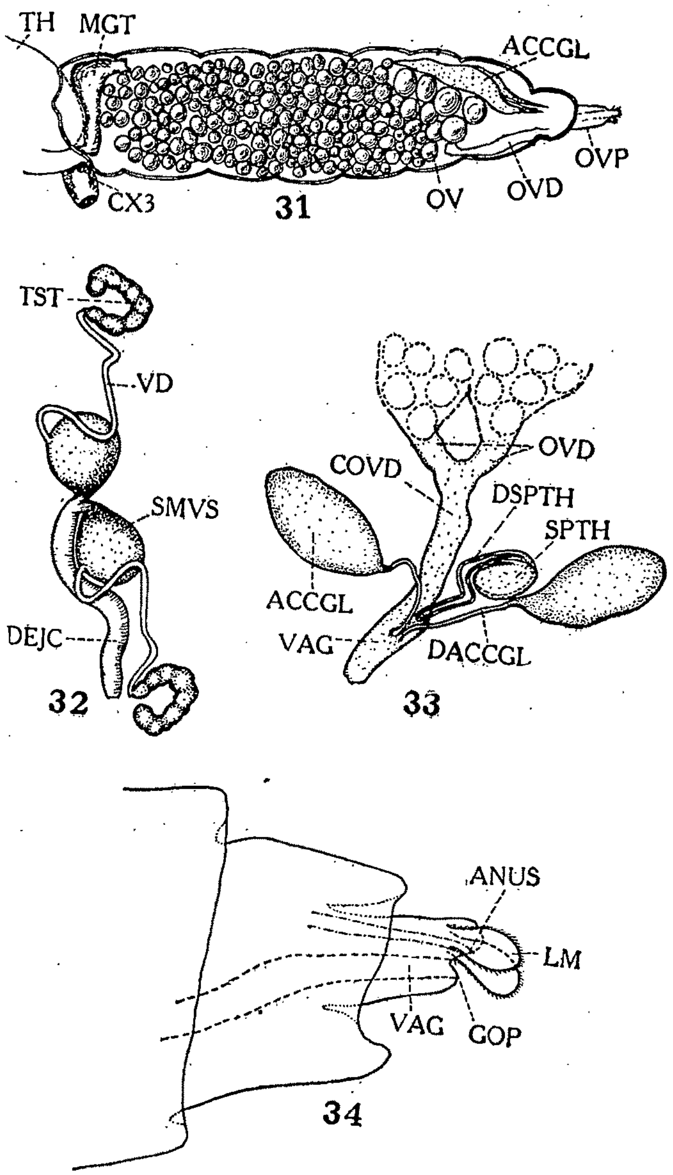
Female

The main organs which constitute the female reproductive system (fig. 33) are a pair of ovaries, a pair of accessory glands (ACCGL) or gluten glands, paired spermathecae (SPTH), the paired oviducts (OVD), the unpaired common oviduct (COVD), vagina (VAG) and the ovipositor (fig. 34).

The ovaries in the adult are no longer present as such. Instead we merely find masses of eggs (fig. 29, 30, 31; OV). The individual ovarioles cannot also be traced. The numerous eggs fill nearly the whole of the abdominal cavity (fig. 31) and as already mentioned, displace the alimentary canal. A thin membranous sheath which covers the egg masses and which may also be ruptured and disintegrated anteriorly, represents whatever remains of the ovarian wall. Posteriorly this sheath is represented by two oviducts (fig. 33, OVD) in the front part of the sixth abdominal segment. The two oviducts meet in the following segment to form a common oviduct (COVD), which is a thick muscular tube extending backward ventrally in the body.

The paired accessory glands (fig. 33, ACCGL) are enormous in size in comparison with other reproductive organs. They lie on the dorsal side of the oviduct and extend from the posterior end of the sixth abdominal segment to about the middle of the eighth segment. Anteriorly they are rather narrow but soon enlarge to one-third of the whole body cavity. The alimentary canal is almost crushed in between these glands. In the eighth segment each gland narrows to form a thread like duct (DACCGL), which empties into the common oviduct (COVD) on the dorsal side, near the anterior margin of the ninth segment. The accessory glands secrete a cementing liquid, which helps in fixing the eggs on the leaf blade during oviposition and have been called on that account as gluten glands by Anderson (1 & 2). Between the gluten glands and the common oviduct are a pair of fairly large spherical spermathecae (SPTH). The two narrow ducts (DSPPH) arise from the antero-dorsal part of the spermathecae, become looped about the thecae before emptying into the oviduct, just anterior to the opening of the ducts of the gluten glands.

After receiving the ducts of the gluten glands and the spermathecae, the common oviduct enters into the muscular vagina (VAG), which runs backwards into the ninth segment and ultimately opens to the outside (fig. 34, GOP) between the two leaf like lamellae (fig. 34, LM) of the ovipositor. The genital opening lies slightly ventral to the anal opening (fig. 34, ANUS), which is also located in between the lamellae but a little posteriorly.



FIGURES 31-34.

31. Female abdominal cavity shown full of ova; 32. Male reproductory organs.
33. Female reproductory organs. 34. Ovipositor.
ACCGL. accessory glands; *ANUS.* anus;
COVD. common oviduct; *CX*3. hind coxa;
DACCCGL. duct of the accessory gland;
DEJG. ductus ejaculatorius; *DSPTH.* duct of the spermatheca; *GOP.* genital opening;
LM. lamellae; *MGT.* mid gut; *OV.* ova;
OVD. oviduct; *OVP.* ovipositor; *SMVS.* seminal vesicles; *SPTH.* spermatheca;
TH. throax;
TST. testes; *VAG.* vagina; *VD.* vasa deferentia.

Ovipositor.—(fig. 34). The ovipositor consists of two oval lamellae (LM), which are attached to the posterior ends of the ninth segment. They are narrow proximally but wider behind. The lamellae are fringed with setae.

Male

The male reproductory system (fig. 32) is comparatively simple. It consists of the paired testes (TST), a pair of seminal vesicles (SMVS), unpaired ductus ejaculatorius (DEJC) and the external male genitalia (figs. 16, 20).

The testes are tubular, convoluted horse-shoe shaped organs, posteriorly communicating with the narrow vasa deferentia (fig. 32,VD). The vasa deferentia at the distal ends enlarge to form two spherical large seminal vesicles (SMVS). Testes and vasa deferentia are generally found coiled round these vesicles. The ducts of the two seminal vesicles join together to form a muscular ductus ejaculatorius (DEJC). The ductus finally opens to the outside in between the male genitalia.

Normally the vesicles may be expected to lie side by side in the body cavity, but in this case they are much displaced and lie one behind the other. The first one lies in the sixth abdominal segment, while the other is located within the seventh abdominal segment. The ducts of the seminal vesicles lie ventrally and join together in between these two to form the ductus ejaculatorius. The ductus then bends round the second vesicle before taking its normal position posteriorly. No accessory gland has been observed.

Male Genitalia.—The external male genital (fig. 16) organs constitute a complex of claspers and plates collectively termed the genitalia. There is a dorsal plate (DP), which is narrowly emarginate and long. Below this lies the ventral plate (VP), which is somewhat shorter but also broader. Apically the ventral plate is broadly incised into two subtriangular obtuse lobes. Ventral to this plate is the slender, long, heavily sclerotized style (STL). On either side of these median and unpaired structures are the paired claspers. The claspers or harpagones are composed of two segments, viz. a short basal clasp segment (BCS) and a short moderately slender, somewhat curved apical clasp segment (TCS), bearing at its tip a black, acute tooth.

Musculature of Genitalia.—(fig. 20). In the male genitalia the musculature is relatively well developed. There are three main muscles. i. extensor of the terminal clasp segment (EXPTC). ii. flexor of the terminal clasp segment (FLXTC). iii. flexor of the basal clasp segment (FLXBC). The first two originate from the outer wall of the basal clasp segment (BCS) and move backwards to become inserted at the base of the terminal clasp segment (TCS). The extensor is inserted on the outer, while the flexor on the inner side.

The flexor of the basal clasp segment is inserted on a conspicuous apodeme on the mesial side near the base of the basal clasp segment. This is the stoutest of the muscles of the genitalia and its contraction, together with that of flexor of terminal clasp segment, brings the harpagones together and thus assist the male in securing a firm grip of the tip of abdomen of female during coitus.

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OPUSCULA LIBELLULOGICA I*

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This paper deals with collections of Odonata received from the Zoology Department, Saugar University; Victoria College, Gwalior and those made by the authors. The type specimens are deposited in the Collections of the Zoological Survey of India, Calcutta.

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Suborder ANISOPTERA
Family GOMPHIDAE
Subfamily ICTINAE

Ictinius rapax (Rambur)

1842. *Diastatomma rapax,* RAMBUR, *Ins. Nevrop; p.* 169.
1854. *Ictinus praecox,* SELYS, *Bull. Acad. Belg.,* **21** : 89.
1922. *Ictinus mordax,* LAIDLAW, *Trans. ent. S.c. London* **78** : 373.
1936. *Ictinus rapax,* FRASER, *Fauna. Brit. India,* Odonata **2** : 373-375.

We refer to this species 1 female 2 males labelled "Sharma Farm, Gwalior 6-ix-53;" 1 male and 1 female Kanskar and Edathiruthy (Saugar).

The specimens before us agree very well with variety *mordax* Selys[1] but differ from Fraser's description (*loc. cit.*) in the following respects.

Male.—Eyes brown to castor seed-coloured; labrum olivaceous-yellow; thorax olivaceous or pale yellow with sutures black; pterostigma covering four to six cells (fig. 4 & 8); discoidal cell with four to seven cells in fore, and two to three cells in hind wing; coxae and trochanter black.

Female.—Wings without dark brown basal markings extending up to the first antenodal nervure.

Family AESCHNIDAE
Subfamily ANAXINAE
Anax marginope, sp. nov.

Female.—Abdomen 44 mm. Hind wing 57 mm. *Head* with labium dirty yellow; labrum coloured same as labium; face and frons olivaceous; frons finely

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[1] SELYS, 1857. Mon. Gomph; p. 433.

bordered with blackish-brown stripe. Posterior half of frons dirty yellow. Vesicle bright yellow with posterior margin black. Occiput brown convex in the middle. *Prothorax* olivaceous, posteriorly yellow. *Pterothorax* greenish-yellow, mid dorsal carina black, but other sutures brown. Humeral area olivaceous with black transverse bands in the middle. Mesepimeron with two-thirds apple-green and anterior one-third black. Metepimeron with one half apple-green, posterior half olivaceous. Anterolateral humeral and posterolateral sutures brown. *Legs* jet-black, base of anterior femora yellowish. *Wings* hyaline and fumed with brown, nervure black; costal margin light brown; pterostigma light brown or ochraceous between black nervures, covering three cells; membrane light yellow; five cells in the discoidal cell in the fore and the hind wings; five cubital nervures in both the wings; hypertrigone traversed twice; twelve cells in the anal loop; nodal index 9-9 / 10-11 (fig. 29 & 30). *Abdomen* brown marked with apple-green, as follows: First segment pale green, second segment apple-green and the rest brown except the large two segments, which have dirty yellow marks. *Anal appendages* blackish-brown;

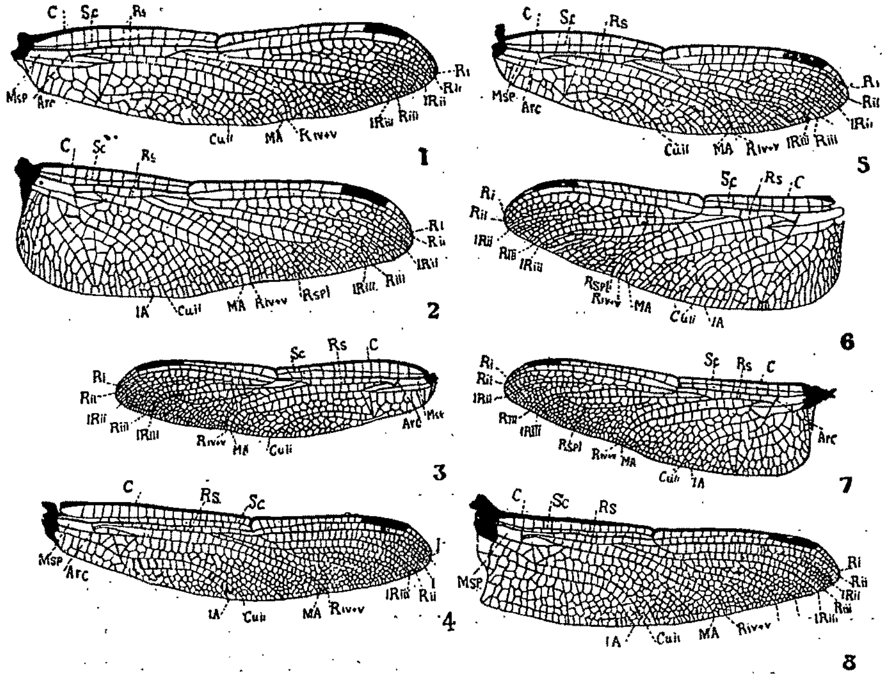


Fig. 1. Fore wing of *Crocothemis servilia servilia* (*Male*)
Fig. 2. Hind wing of *Crocothemis servilia servilia* (*Male*)
Fig. 3. Fore wing of *Orthetrum sabina*. (*Male*)
Fig. 4. Fore wing of *Ictinius rapax* (*Male*)
Fig. 5. Fore wing of *Potamarcha obscura* (*Female*)
Fig. 6. Hind wing of *Potamarcha obscura* (*Female*)
Fig. 7. Hind wing of *Orthetrum sabina* (*Male*)
Fig. 8. Hind wing of *Ictinius rapax* (*Male*)

superior lanceolate as shown in the figure 42; inferior not quite half the length of the superior.

Holotype female, Coll. Shanti Misra, Davis House, Agra, at light; August 23, 1954.

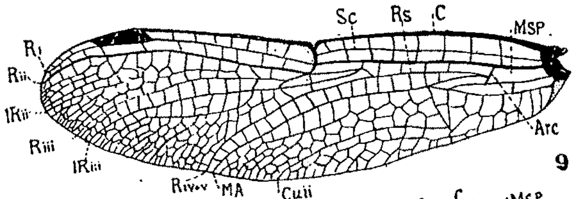
This species is distinguished from *Anax parthenope* by brown occiput; frons bordered with blackish-brown stripe; olivaceous prothorax; and in the marking of pterothorax and abdomen.

Family LIBELLULIDAE

Subfamily LIBELLULINAE

Lathrecista asiatica asiatica (Fabricius)

1798. *Libellula asiatica*, FABRICIUS, *Ent. Syst. Suppl.*, p. 283.
1890. *Lathrecista asiatica*, KARSCH, *Berlin. ent. Z.*, **38** : 369.
1936. *Lathrecista asiatica astiatica*, FRASER, *Fauna Brit. India*, Odonata, **3** : 281-284.



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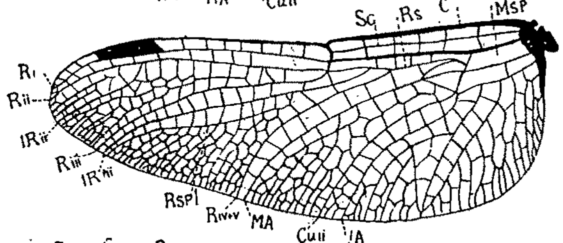

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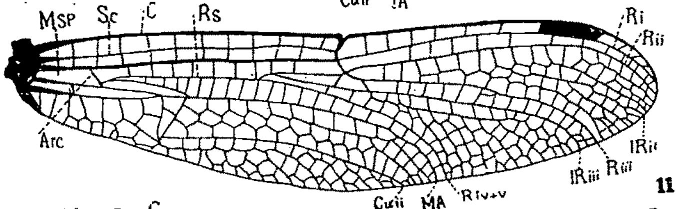

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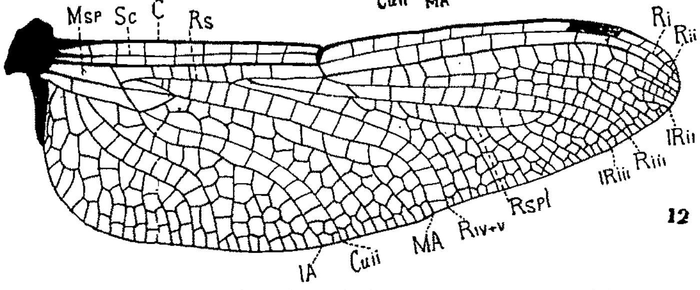

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Fig. 9. Fore wing of *Brachythemis contaminata* (Male)
Fig. 10. Hind wing of the same
Fig. 11. Fore wing of *Zyoxomma petiolatum* (Male)
Fig. 12. Hind wing of the same.

We refer to this species 1 female labelled "Trichur, Coll. Bala, 15.x. 1952." It differs from Fraser's description (*loc. cit*) as below: The upper surface of the frons not steely-black or metallic blue-black but dirty greenish-yellow; vesicles and occiput not black or metallic blue but brown; markings on the thorax variable; two rows of cells between IRiii and Rspl (fig. 13 & 14); colour of abdomen faded reddish-brown, otherwise as described; eight abdominal segment with two lateral expansions.

This species is already known to occur in Western India to Samoa, Sundaic Archipelago, Borneo, New Guinea.

This is the first record of this species from South India.

Potamarcha obscura (Rambur)

1842. *Libellula obscura*, Rambur, *Ins., Nevrop.* p. 64.
1890. *Potamarcha obscura*, Karsch, *Berlin. ent. Z.* **33** : 371.
1924. *Potamarcha obscura*, Frasser, *Rec. Indian Mus.* **26** : 426-432.
1936. *Potamarcha obscura*, Frasser, *Fauna Brit. India*, Odonata. **3** : 289-291.

In the single female labelled "Moti Jheel; Gwalior, 24-ix-53." before us the frons is brownish-yellow, thorax olivaceous-yellow, legs brown, wings as in figure 5 & 6, long and narrow with close reticulation, discoidal cell of fore wing narrow and traverse, hypertrigones entire, Cuii arising from the posterior angle of discoidal cell, arch lying between first and second antenodal nervures, only one cubital nerve, discoidal field beginning with three rows of cells, one or two rows of cells between IRiii and Rspl.

This species is known from the whole of India, Tibet, Ceylon, Philippines and Formosa.

Orthetrum pruinosum neglectum (Rambur)

1842. *Libellula neglecta*, Rambur, *Ins. Nevrop.* p. 86.
1886. *Orthetrum pruinosum*, Kirby, *Proc. Zool. Soc. London*, p. 327.
1936. *Orthetrum pruinosum neglectum*, Fraser, *Fauna Brit. India*, Odonata. **3** : 312-313.

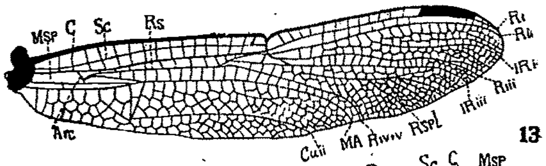
One male "Sharma Farm, Gwalior; 6-ix-53" differs from the published description of the species in the following respects:—Length 52 mm. Abdomen 35 mm. Thorax light blue dorsally and with a testaceous tinge laterally extending very far. Wing unfumed pale brown as far as the node and along the basal side upto anal loop, the rest white membranous, two rows of cells between IRiii and Rspl, discoidal cell in the hind wing two celled. Abdomen dilated at the base and somewhat conical as far as segment third.

This is one of the commonest species occuring throughout India and has also been recorded from Ceylon, Burma, Tibet, Indo-china and Hongkong.

Orthetrum cancellatum cancellatum (Lidn.)

1758. *Libellula cancellata,* LINN. *Syst. Nat.* **10** (1) : 544.
1874. *Orthetrum cancellatum,* MAYR-Din, *Mitt. Schwaz. ent. Ges.* **4** : 330.
1918. *Orthetrum cancellatum cancellatum,* FRASER, *J. Bombay Nat. Hist. Soc.* **26** : 156-157.
1936. *Orthetrum cancellatum cancellatum,* FRASER, *Fauna Brit. India.* Odonata. **3** : 302-304.

One male "Collected from Sushila Kothi, Gwalior, 7-x.-53." differs from the published account in the following respects. Prothorax dark brown. Pterothorax purinosous-blue at the dorsum, pale brown antero-dorsally, oblique stripes dark brown. Legs dark brown on the upper side and yellow beneath upto tarsus; pterostigma reddish-brown, covering two cells, two rows of cells between IRiii and Rspl; arc between the first and second antenodal nervure; Cuii arising from the posterior angle of discoidal cell in hind wing.



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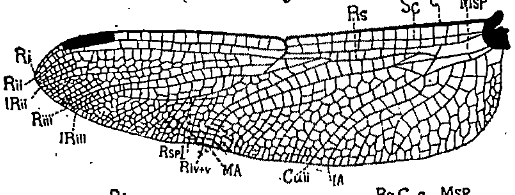

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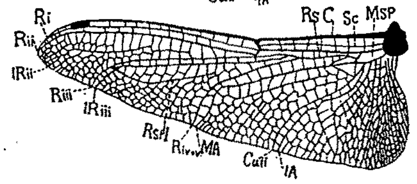

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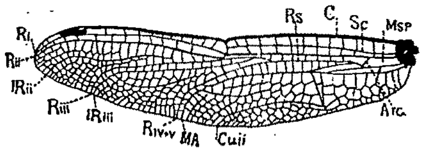

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Fig. 13. Fore wing of *Lathrecista asiatica asiatica* (Male)
Fig. 14. Hind wing of the same.
Fig. 15. Hind wing of *Tramea basilaris burmeisteri* (Male)
Fig. 16. Fore wing of the same.

Abdomen.—First five segments concolourous with the dorsum of the thorax (Prinosable) rest including anal appendage blueblack; first three segments olivaceous beneath, which is lesser on the second and still lessor in the third. There are no black spots beneath. Anal appendages variable.

This species is being recorded here for the first time from the Oriental faunal zone in India. It was previously known from the Palearctic of India (Kashmir) and of Europe.

Orthetrum sabina (Drury)

1770. *Libellula sabina*, DRURY, *Ill. Exot. Ins.* **1** : 114-115.
1889. *Orthetrum sabina*, KIRBY, *Trans. Zool. Soc. London*, **12** : 302.
1924. *Orthetrum sabina*, FRASER, *J. Bombay Nat. Hist. Soc.* **20** : 426. 432.
1936. *Orthetrum sabina*, FRASER, *Fauna Brit. India*, Odonata, **3**: 300-302.

We have before us 5 males "Murhar, at light, 6-xi-52;" "Moti Jheel, Gwalior, 18-ix-53" and 1 "Edathiruthy (Sagar), 11-21-x-52, Coll. Bala;" and 4 females two labelled "Edathiruthy (Sagar), 19-x-52, Coll. Bala;" "Moti Jheel, Gwalior, 24-ix-53" and two from "N. T. Park Murhar on light, 10-x-52."

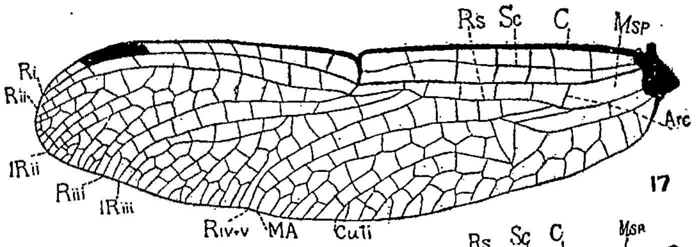
Male.—Abdomen 30-42 mm. Hind wing 30-42 mm. Labium creamy-white to yellow; labrum yellow to dark brown; face and frons light to dark olivaceous; prothorax varying from bright yellow to yellowish-green. Colour of the thorax pale green to bright green. Pterostigma obscure yellow, white membrane in some specimens, (fig. 3 & 7). Abdomen greenish-yellow to creamy-white beyond its swollen end. The oval dorsal spot in segments 4-6 varies in length and its colour like those of compressed segments varies from deep black to brown. Anal appendages creamy-white sometimes with a yellowish tinge.

Female.—Female also differs in the same points and the colour of the anal appendages, are creamy-white to pale-yellow.

This is widely distributed species known to occur in Somaliland, Israel, Persia to Samoa, whole of India, Ceylon, Burma and Siam.

Orthetrum taeniolatum (Schneider)

1845. *Libellula taenilata*, SCHNEIDER, *Steil. ent. Z.* **6** : 11.
1890. *Orthetrum taeniolatum*, KIRBY, *Cat. Odon. p.* 37.
1918. *Orthetrum taeniolatum*, FRASER, J. *Bombay Nat. Hist. Soc.* **26** : 160-161.
1936. *Orthetrum taeniolatum*, FRASER, *Fauna Brit. India*, Odonata, **3** : 296-298.



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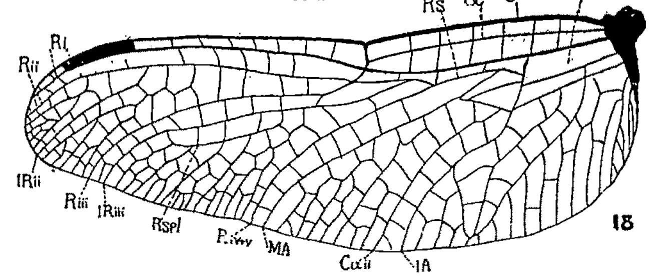


18

Fig. 17. Fore wing of *Acisoma panorpoides panorpoides* (Female)
Fig. 18. Hind wing of the same.

One male "Sharma Farm Gwalior, 6-ix-53" Clypeus and frons light brown; femur pulverulent-blue. Abdomen uniformly blue-black, except at the base where it is frosted with blue upto first segment. Anal appendages devoid of blue frostation. Pterostigma ochraceous, borderd black, covering two cells. One to two rows of cells between IRiii and Rspl, Cuii in hind wing arising from posterior angle of discoidal cell or somewhere remote from it. Common in drier parts of India.

Acisoma panorpoides panorpoides (Rambur)

1842. *Acisoma panorpoides*, Rambur, *Ins. Neur.*, p. 28.
1919. *Acisoma panorpoides*, Fraser, *J. Bombay Nat. Hist. Soc.* **26** : 493.
1936. *Acisoma panorpoides*, Fraser, *Fauna Brit. India*, Odonata, **3**: 330-331.

One female "Moti Jheel, Gwalior, 18-ix-53" Eyes not spotted yellow; the fine line described by Frasser crossing epistome absent, anal appendages light-blue, wings hyaline; discoidal field with two rows of cells; costal cell of discoidal cell in fore wing angulated; pterostigma pale yellow, covering more than one cell (fig. 17 & 18).

This species is common in whole of India, Ceylon, Philippines, China, Java, Sumatra and Celebes.

Crocothemis servilia servilia (Drury)

1770. *Libellula servilia*, Drury, *Ill. exot. Ins.*, **1** : 112.
1868. *Crocothemis servilia*, Brauer, *Verh. Zool. Bot. Ges. Wien.* **18** : 737.
1919. *Crocothemis servilia servilia*, Fraser, *J. Bombay Nat. Hist. Soc.* **26** : 516-517.
1936. *Crocothemis servilia servilia*, Fraser, *Fauna Brit. India*, Odonata **3** : 345-347.

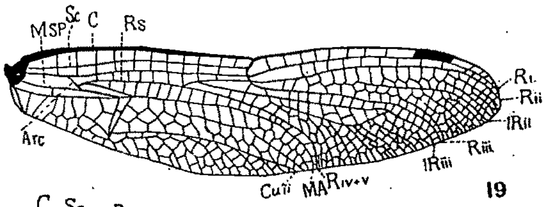
We have before us 10 males and one female labelled "Moti Jheel, (specimen no. 6, 13, 14, 17, 18) collected on 18-14-ix-53;" Susera Kothi, Gwalior. (Specimen no. 12, 14, 14 a) collected on 7-x-53 and Sagar (specimen no. 44 & 46), coll. S. D. Misra; 17-x-51."

Labium ferruginous dark brown to creamy-red; labrum in two specimens also dark brown to dirty yellow; frons violet-red and face sometimes dirty yellow; occiput orange to red. Thorax brown-orange; blue or red marked with five black sutures in the lateral half. Legs orange with a red marking on tibia outwardly, to fully black. Wings with blood red venation; in few species basal markings light or deep yellow and varying in length. Pterostigma variable in colour (fig. 1 & 2); Cuii arising from posterior angle of discoidal cell; discoidal field beginning with three rows of cells widely divergent at wing border. Anal appendages coloured as abdomen.

Female similar to the Fraser's description given in the Journal of Bombay Natural History Society.

Crocothemis misrai, sp. nov.

Male.—Abdomen 24 mm. Hind wing 29 mm. *Head.* labium and labrum blackish-brown; anticlypeus pale-yellow; frons purple; vesicle and occiput brown with purple tinge, eyes chocolate coloured, deep brown laterally. *Prothorax* purple black; posterior lobe with black margin. *Pterothorax* purple brown on the dorsum; light chocolate coloured laterally with sutures finely margined with black. *Legs.* black; outer tibia reddish. *Wings* hyaline; marked with dark brown to as far as the first antenodal nervure in fore wing (fig. 23 & 24) and going parallel to it upto the distal margin; encircling the second antenodal nervure; arculus and first row of cells of anal loop towards basal side in hind wing in such a way that the patch becomes some what bow shaped; apices of wing clear. All veins colour red; pterostigma pale brown, equal in fore and hind wings. *Abdomen* first three basal segments opaque brown having a reddish tinge on second segment, segments three to nine light brown with a keel, and



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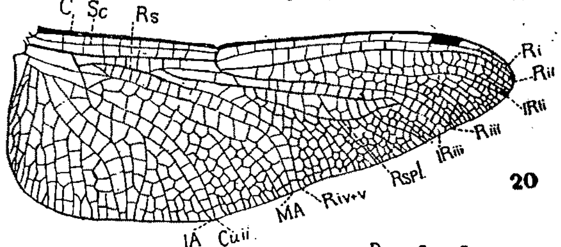

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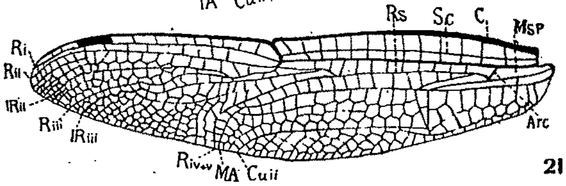

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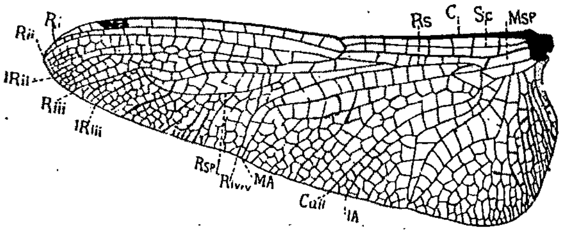


22

Fig. 19. Fore wing of *Tholymis tillarga* (Male)
Fig. 20. Hind wing of the same.
Fig. 21. Fore wing of *Hydrobasileus croceus* (Male)
Fig. 22. Hind wing of the same.

compressed laterally becoming narrow towards the end. *Anal appendages* pale brown; superior and inferior nearly of the same length (fig. 41). *Genitalia* as in figure 38.

Holotype male, Saugar (M. P.), Coll. S. D., Misra, 17-x-51.

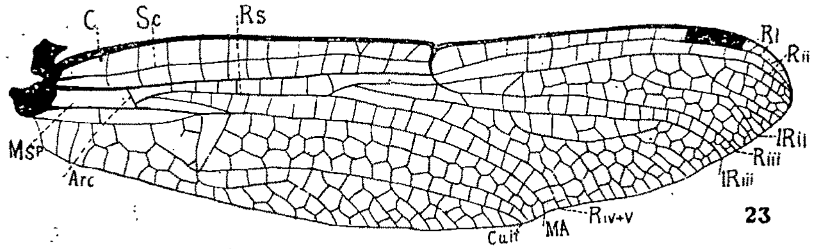
This species is distinguished from *Crocothemis servilia servilia*[1] by the blackish-brown colour of the labium and labrum; purple frons; purple tinge on the dorsum of pterothorax and the light brown colour of the abdomen and genitalia.

Bradinopyga geminata (Rambur)

1842. *Libellula geminata*, Rambur, *Ins., Nevrop*, p. 90.
1911. *Bradinopyga geminata*, Ris, *Cat. Coll. Selys*, **13** : 545.
1919. *Bradinopyga geminata*, Fraser, J. *Bombay Nat. Hist. Soc.* **26** : 514-515.
1936. *Bradinopyga geminata*, Fraser, *Fauna Brit. India*, Odonata **3** : 349-350.

One female "Indian Agricultural Research Institute, New Delhi; Coll. D' Souza, 12-viii-50," and one male and one female "Murhar (Gwalior), 18-x-52, at light."

Male.—Labium creamy white; frons dark brown; eyes uniformly dark brown; thorax and abdomen light brown marbled with blackish-brown. Wings hyaline; pterostigma black at centres, dotted white at proximal and distal ends; discoidal field beginning with three row of cells (fig. 25 & 26).



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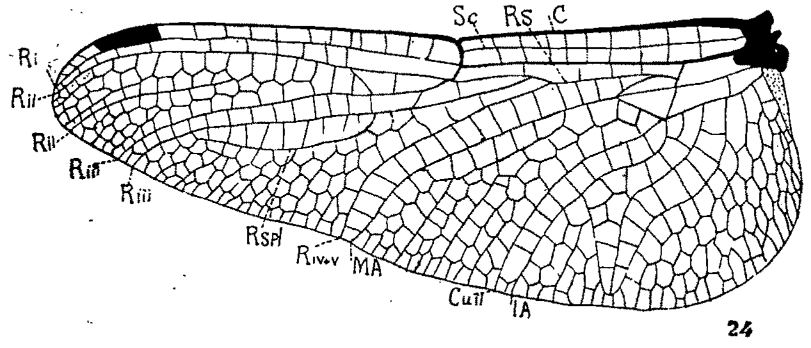

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Fig. 23. Fore wing of *Crocothemis misrai*, sp. nov. (Male)
Fig. 24. Hind wing of the same.

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[1] Fraser, F. C. 1936. Fauna Brit. India, Odonata 3: 345.

Female. similar to male except face and labrum pale yellow.

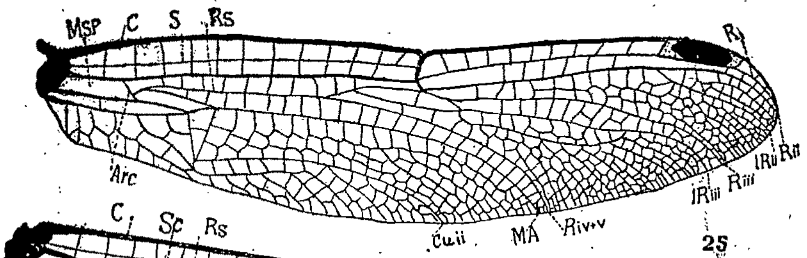
This species is already known to occur in peninsular India.

Bradinopyga saint-johanni, sp, nov.

Male.—Abdomen 29 mm. Hind wing 38 mm. *Head* labium blackish brown with two yellow dots ventrally; labrum dark brown with pale yellow posterior margin; rest of the face and frons blackish-brown with violet reflection; vesicle and occiput brown; eyes brown somewhat blackish below traversed by a finely yellow oblique line. *Prothorax* anterior lobe with a yellow margin somewhat pruinose with blue, posterior lobe small, without setae. *Pterothorax* uniformly blue-black; mesothorax with somewhat whitish tinge. *Legs* blue-black. *Wings* hyaline; with deep black venation (figs. 27 & 28); pterostigma black in the middle, pale white distally and proximally; two rows of cells between IRiii and Rspl; discoidal cell traversed; discoidal field beginning with four rows of cells, which later become three; fore wing marked with yellow in cubital space like the hind wing, which is also marked further below. *Abdomen* wholly blue-black, without any yellow markings; dilated at the base and become conical upto segment four where it is cylindrical and then is compressed laterally. *Anal appendages* white with greenish tinge (fig. 40). *Genitalia* as in figure 43.

Holotype male, loc: tank in the garden, St. John's College, Agra; 26-vii-54; Coll: J. P. Agarwal. They were also found abundantly near the coal gas plant.

This species can readily be separated from *Bradinopyga geminata** by the



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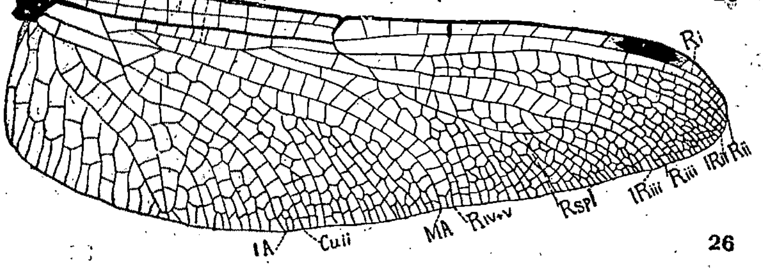

26

Fig. 25. Fore wing of *Bradinopyga geminata* (Female)
Fig. 26. Hind wing of the same.

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*Frares, F. C. 1936. *Fauna Brit. India,* Odonata 3 : 349-350.

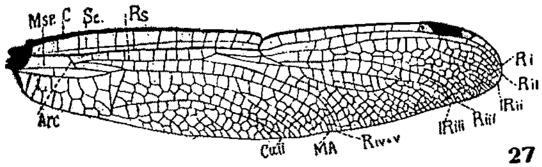
dark brown labium with spots; blackish-brown face, blue-black thorax and abdomen; shape of the abdomen; discoidal field begining with four cells; discoidal cell traversed; yellowish tinge in fore and hind wing; the colour of the pterostigma at the distal and proximal ends.

Neurothemis fulvia (Drury)

1773. *Libellula fulvia*, DRURY, *Exot. Ins.* **2** : 46.
1869. *Neurothemis fulvia*, KIRBY, *Trans. Zool. Soc. London*, **12** : 271.
1919. *Neurothemis fulvia*, FRASER, *J. Bombay Nat. Hist. Soc.* **26** : 507-509, 510.
1936. *Neurothemis fulvia*, FRASER, *Fauna Brit. India*, Odonata, **3** : 353-354.

We have before us males "Col. Edathiruthy (Sagaur) by Bala, 20-x-52."

Labium creamy yellow to bright ochreous; face, frons, and vesicles varying from olivaceious-pale to ochraeous. There is a good deal of difference in the colour of these specimens, one has light golden-brown throughout, while the second one is somewhat dark brown when the last is deep opaque dark in colour. Wings opaque dark reddish brown except for an irregular triangular area at apices of wings; the whole of dark area very finely and closely reticulated



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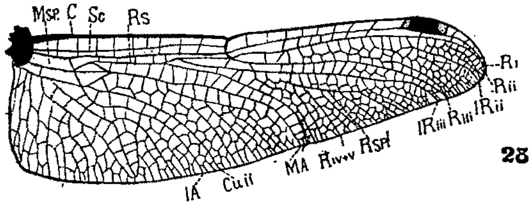

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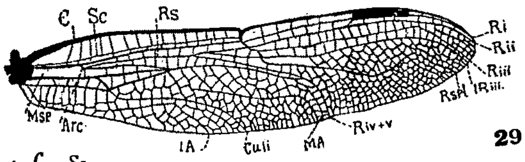

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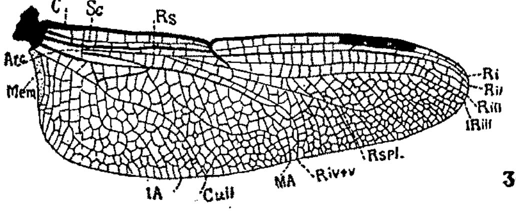

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Fig. 27. Fore wing of *Bradinopyga saint johanni* (Male)
Fig. 28. Hind wing of the same.
Fig. 29. Fore wing of *Anax marginope* (Male)
Fig. 30. Hind wing of the same.

by bright yellow nervures except in the clear spaces; antenodals and post nodals adjacent the node breaking up into net work of secondary nuration. Ten cubital nerves in fore wing six in hind wing, pterostigma dark reddish-brown (figs. 46 & 47).

This is common throughout India, Burma, Malacca, Siam and Indo-China.

Neurothemis tullia tullia (Drury)

1773. *Libellula tullia*, DRURY, *Ill. exot. Ins.*, **2** : 85. pl. xivi, fig. 3.
1890. *Neurothemis tullia*, KIRBY, *Cat. Odonata*, **18** : 718.
1936. *Neurothemis tullia tullia*, FRASER, *Fauna Brit. India*, Odonata, **3** : 360-362.

We refer to this species 2 females and 5 males "Band Baretta (Bharatpur) garden near lake, coll: J. P. Agarwal and H. N. Baijal, 11-ix-54."

In male labrum violet black; mid dorsal carina of the thorax varies in different specimens from pale yellow, black to rusty; creamy white stripe on the abdomen absent; pterostigma dark brown. Wing male hyaline for apical half, opaque steely blue-black for basal half; the border of this opaque area running in both fore and hind wings from coastal border, one cell distal to node in fore wing, two or three cells distal in hind to the posterior border of wings in a convex cover (fig. 50 & 51). Pterostigma ochreous. Female wing as in figures 48 & 49.

This species is known throughout peninsular India, Burma, Malacca, Indo-China and Hongkong.

Brachythemis contaminata (Fabr.)

1793. *Libellula contaminata*, FABRICIUS, *Ent. Syst.* **2** : 382.
1868. *Brachythemis contaminata*, BRAUR, *Verh. Zool. Bot. Ges. Wien.*, **28** ; 376.
1919. *Brachythemis contaminata*, FRASER, *J. Bombay Nat. Hist. Soc.*, **26** : 738-739.
1936. *Brachythemis contaminata*, FRASER, *Fauna Brit. India* Odonata **3** : 365-366.

We collected 12 males and 14 females of this species from Band Beretta on 11-ix-54 in noon, 2 males and 1 female from Dayalbagh canal, Agra: coll: J. P. Agarwal and H. N. Baijal, 1-viii-54. and 2 males" Sharma farm, Gwalior.

They were abundant in the garden near lake in Band Baretta and along the road near the tank. Male and female were almost equal in number and there is so much of sexual dimorphism that at first sight they appear as distinct species. It was also not uncommon to find them in Agra along the side of ditches and sewage pipes.

The colour of abdomen varies from deeper ochreous to dark brown, the golden tinge in the wing of male which perhaps varies with the age, extends in some cases upto the posterior wing margin. While in other it stops as a simple patch on the anterior margin only. Labium and labrum varying from deep yellow to light yellow, while that of frons from ochreous to light yellow, three cells in pterostigma. Nodal index $\left(\frac{6\text{-}7\text{-}1/2/}{5\text{-}6.}\Big/\frac{7\text{-}1/2\text{-}6}{5\text{-}6.}\right)$ only one row of cell between IRiii and Rspl; discoidal cell beginning with three row of cells (figs. 9 & 10). Anal appendages ochreous and like last abdominal segment. In certain specimens of female there is slight appearance of tinge in the hind wing while in others it is totally obliterated. The markings of the abdomen also varies slightly.

The specimen is very common throughout the plains of India, Ceylon, Burma, China, Formosa, Java, Sumatra and Philippines.

Zyxomma petiolatum Rambur.

1842. *Zyxomma petiolatum*, RAMBUR, *Ins. Nevrop.*, p. 30.
1920. *Zyxomma petiolatum*, FRASER, *J. Bombay Nat. Hist. Soc.* **27** : 256-257.
1936. *Zyxomma petiolatum*, FRASER, *Fauna Brit. India*, Odonata, **3** : 409.

One male from "Edathiraty (Sagaur), col: Bala, 19-x-52."

Pterostigma dark black-brown, wings deeply enfumed with brown and with apices dark brown to slightly proximal of inner and of peterostigma (figs. 11 & 12). Anal appendages pale brown, with the apices black.

The species occur throughout India.

Tholymis tillarga (Fabr.)

1798. *Libellula tillarga*, FABRICIUS, *Ent. Syst.* (*Supp*), p. 285.
1867. *Tholymis tillarga*, HAGEN, *Stett. ent. Z.*, **28** : 220.
1920. *Tholymis tillarga*, FRASER, *J. Bombay Nat. Hist. Soc.* **27** : 254-255.
1936. *Tholymis tillarga*, FRASER, *Fauna Brit. India*, Odonata, **3** : 411-412.

We have before us one male specimen from Trichur, 15-x-52, coll: Bala.

Labium and face brown; labrum, clypeus, anteclypeus faded brown. Abdomen golden yellow swollen at the base, becomes cylindrical from third to sixth segments and again dilates in seventh and eighth segments. Wings hyaline with a broad fan shaped smoky golden brown fascia extending from node to base of hind wing, deep in colour at node paling towards base and posterior border of wing; pterostigma reddish-brown between dark nervures; membrane blackish-brown (figs. 19 & 20).

This species in common throughout India, Ceylon, and Burma to Australia.

Rhyothemis variegata variegata (Linn.)

1763. *Libellula variegate*, LINN., *Ameonitates Acad.*, **6** : 412.
1867. *Rhyothemis variegata*, HAGAN, *Stett. ent. Z.*, **28** : 232.
1924. *Rhyothemis variegata variegata*, FRASER, *Rec. Indian Mus.*, **26** : 426, 443.
1936. *Rhyothemis variegata, variegata* FRASER, *Fauna Brit. India*, Odonata, **3** : 423-424.

We refer to 2 female specimens from Band Baretta collected by H. N. Baijal from garden near lake on 11-ix-54.

Wings as in figures 45 & 44. This agrees in all details with the published description. This species is common throughout India, Ceylon, Burma, and Malaysia.

Hydrobasileus croceus (Brauer)

1867. *Tramea croceus*, BRAUER, *Verh. Zool. Bot. Ges., Wein,* **17** : 813.
1890. *Hydrobasileus croceus*, KARSCH, *Berlin ent. Z.*, **33** : 351.
1920. *Hydrobasileus croceus*, FRASER, *J. Bombay Nat. Hist. Soc.* **27** : 56.
1936. *Hydrobasileus croceus*, FRASER, *Fauna Brit. India* Odonata, **3**: 42-430.

We have before 21 females and 7 males collected from Sawai Madhopur (Rajasthan) by Y. K. Rathore near Bhairon Gate. We also collected 14 males and the same number of females from the grassy plot facing the St. John's college, main building on 6. viii. 54. 2 males from Saugar collected by D. S. Misra on 21. x. 51. They were hovering almost everywhere in Agra in the Bazars just above telegraphic lines, on the railway lines, in garden, near tanks or pools during August and September. We also saw them resting on the twigs of neem tree dan two or three times we saw a few in our room in the morning lying on the floor.

Sawai Madhopur Collection Abdomen 32-35 mm. hind wing 40-45 mm. labium dirty brown to olivaceous; face bright yellow to deep olivaceous; frons yellow in some cases; clypeus, anteclypeus olivaceous or the other way right thorax olivaceous with varying amount of golden tinge pterostigma very short, the pale tinge differs in six from a slight patch near the base upto four cells to the distal side of the anal loop; wings hyaline, membranous or diffused reddish-brown throughout the entire length. Abdomen segment 10 not black; in some cases covered on the ventral side with silvery ash colour, extending upto sixth segment, blackish brown colour replacing golden yellow in some specimen. Anal appendages reddish-brown becoming dark brown at the tips.

Agra Collection Labium dark brown with yellow dots; labrum, clypeus, anteclypeus, olivaceous yellow to deep termeric yellow; tibia black; hind wing with a golden yellow patch at the tips in some specimens which may also be present in fore wing though very small; membrane white; veins largely black, transparent membranous or hyaline. Abdomen as described in specimens collected from Sawai Madhopur, sometimes blackish-brown throughout; brightsil very tinge pronounced at the base and may extend ventrally, laterally or both upto the last segment embracing some or all the segments; olivaceons colour at base having tendency to change to golden, dark brown or to blackish-brown.

This is a common oriental species.

Tramea basilaris burmeisteri (Kirby)

1862. *Libellula basilaris*, HAGAN, *Paters Reize Nach. Mossclvirque Zool.* **5** : 105.
1889. *Tramea burmeisteri*, KIRBY, *Trans. Zool. Soc. London* **12** : 316.
1936. *Tramea basilaris burmeisteri*, FRASER, *Fauna Brit. India*, Odonata, **3**: 432-434.

We have before us 4 males labelled "Band Baretta garden near lake, collector J. P. Agarwal and H. N. Baijal, 11-ix-54." "N. T. Park, Murhar, 8-x-52" and 2 "Sagur on hill, coll: S. D. Misra, 21-x-51."

Length 50-54 mm. Hind wing 40-45 mm. Labium pale yellow; labrum dark brown, colour deep at border; anteclypeus and post clypeus light red in some, frons varying from reddish-brown to dark brown; antennae long; occiput yellow to dark brown. Prothorax olivaceous yellow, anterior lobe small and without black border and setaceous. Wings long very broad at base; nervures coloured red, in some two dark brown sometimes violet spots in the hind wing with golden yellow back ground; one cubital nervure (figs. 15 & 16); Cuii arising from posterior angle of the discoidal cell; discoidal field beginning with four rows of cells; two rows of cells between IRiii and Rspl; anal loop dilated at the apex having 35 cells; pterostigma unequal pale yellow to dark brown.

This is common throughout India, Ceylon, Burma and Malaysia.

Suborder ZYGOPTERA
Family COENAGRIIDAE
Subfamily Synlestinae

Orolestes motis, sp. nov.

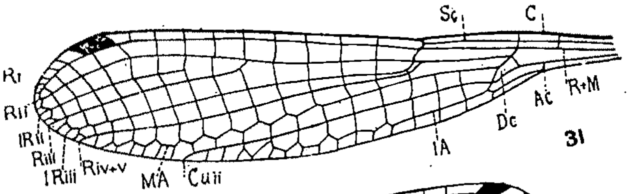
Male.—Abdomen 36 mm. Hind wing 24 mm. *Head* labium yellow; labrum brown; anteclypeus dark brown; postclypeus, frons, vertex, occiput all brown but the latter with blackish tinge; eyes dark brown (fig. 37). *Prothorax* brown with dark brown colouration at sides and mid dorsum *Pterothorax* brown; deep brown at sides close by and in the mid dorsum, yellow laterally; antehumeral stripe reddish brown unfirmly yellow ventrally. *Legs.* yellow at the base and the outer side of femur; rest dark brown; spines very long. *Wings.* hyaline (fig. 33); uncoloured; pterostigma golden brown, braced, covering two cells; postnodal nervure ten in fore and hind wings; ac and ab in the hind wing meeting at the hinder border of the wing; discoidal cells very acutely pointed distally. *Abdomen* comparatively very short, cylindrical; compressed at segments sixth and then somewhat dilated distally; colour brown dorsally which takes blackish tinge as we go distally; finely black at joints; two blackish spots at the joint on either side of the keel like on the dorsum in every segment. A blackish line bordered with white running throughout the ventral sides. *Anal appendages* (fig. 42) brown; forcipate; superior much longer than segment tenth; apices meetng or even overlapping; somewhat twisted; inferior appendages shorter, robust with spine directed upwards and anal words.

Female.—similar to male except, labrum dark reddish brown with a dark brown lining; face with yellowish tinge; legs with dark brown stripes throughout. Abdomen uniformly dark brown with the same colour patterns as in the male, small spiny process fringing the joints in each segment at the distal end. Anal appendages brown, shortly conical and pointed.

Holotype male, *Allotype* female; Moti Jheel Gwalior; 18-ix-53.

This species is easily separated from *Orolestes selysi* by the following characters:—

Hind wing smaller in length; brown labrum; rest of the head brownish and not blackish; absence of olivaceous tinge in prothorax and pterothorax; legs



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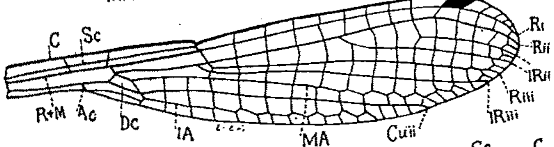

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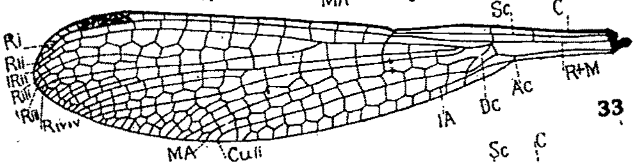

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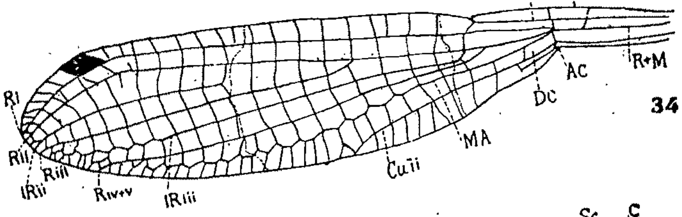

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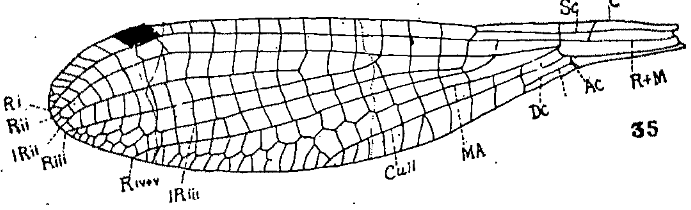

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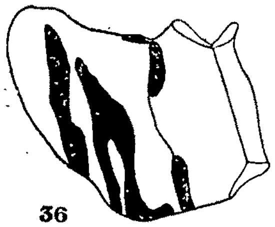
Fig. 31. Fore wing of *Coenagrion olivaceum* (Female)
Fig. 32. Fore wing of *Coeriagrion coromandelianum* (Female)
Fig. 33. Fore wing of *Orolestes motis, sp. nov.*
Fig. 34. Fore wing of *Platylestes orientalis,* sp. nov.
Fig. 35. Hind wing of the same.

yellow at the base; golden-brown pterostigma; and colour and markings of abdomen and anal appendages.

Subfamily Lestinae

Platylestes orientalis, sp. nov.

Male.—Abdomen 40 mm. Hind wing 24 mm. *Head* labium brown and labrum yellow; postclypeus brown with posterior margin black; frons, vertex and occiput brown with margins black. *Pterothorax* brown with sutures black and with a narrow oblique black stripe on each side mapping out the postero-lateral suture. *Legs* olivaceous; hind femora with black stripe along the exterior surface. *Wings* (figs. 34 & 35) hyaline at base and apex, brown from fourth postnodal nervure to pterostigma in the fore wing but in hind wing the brown marking extends from first postnodal nervure to ninth post nodal nervure and not upto the pterostigma; pterostigma brown framed in heavy black nervure, twice as long as broad, outer border not straight, costal border little longer than posterior covering only one cell; 12 postnodal nervures to fore wing; 17 postnodal nervures in hind wing; ac oblique and meeting ab not near the posterior margin of the wings; other features of venations as for the genus. *Abdomen* brown except the last three segments which are black; the abdominal segments on lateral sides also



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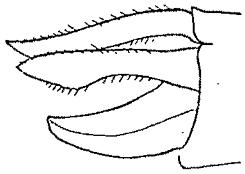

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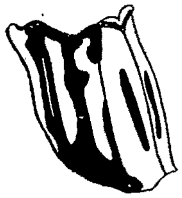

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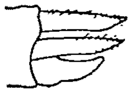

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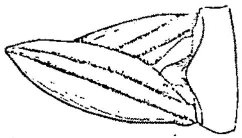

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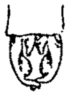

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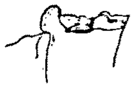

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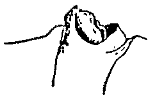

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Fig. 36. Thorax of *Crocothemis misrai*, sp. nov.
Fig. 37. Thorax of *Orolistes motis*, sp. nov.
Fig. 38. Lateral view of the genitalia of *Crocothemis misrai*, sp. nov.
Fig. 39. Dorsal view of the anal appendages of *Orolestes motis*, sp. nov.
Fig. 40. Lateral view of anal appendages of *Bradinopyga saint johanni*, sp. nov.
Fig. 41. Lateral view of anal appendages of *Crocothemis misrai*, sp. nov.
Fig. 42. Lateral view of anal appendages of *Anax marginope*, sp. nov.
Fig. 43. Lateral view of genitalia of *Bradinopyga saint johanni.*, sp. nov.

black. *Anal appendages* Superior black broad at base; inferior yellow as long as superior with apices acute.

Holotype male collected from Delhi by M. Bose; 10. viii. 53.

This species differs from *Platylestes platystyla* in the following respects:—Labium brown; labrum yellow; black spots at the base of post clypeus absent; pruinose, and black spots at the thorax absent; legs olivaceous; wings hyaline pterostigma twice as long as broad; abdomen brown changing to black.

Subfamily Coenagriinae

Coriagrion coromandelianum (Fabr.)

1798. *Agrion coromandelianum*, Fabr., *Ent. Syst. Suppl.*, p. 287.
1876. *Ceriagion cormandelianum*, Selys, *Bull. Acad. Belg.*, (2) **42** : 528.
1911. *Ceriagion cormandelianum*, Fraser, *J. Bombay Nat. Hist. Soc.* **27** : 542.
1933. *Ceriagrion cormandelianum*, Fraser, *Fauna Brit. India*, Odonata, **1** : 315-316.

We collected 8 males and 7 females from the Botanical Garden, St. John's College, Agra, hovering near the tank, and settled on the grass; 17-23-viii-54

Labium, labrum and mandibles with dark brown borders; occiput and post occular area not ochreous as described by Fraser in some specimens. Wings (figs. 32) hyaline; 11-12 post nodal nervure in fore wing, and 9-11 in hind wing. Abdomen with olivaceous tinge on the dorsum and laterally which is pronounced at joints. It is distributed throughout India, Ceylon, Burma, Malaysia, Indo-China and South China.

Ceriagrion olivaceum Laidlaw

1914. *Ceriagrion olivaceum*, Laidlaw, *Rec. Indian Mus.*, **8** : 345-346.
1923. *Ceriagrion olivaceum*, Fraser, *J. Bombay Nat. Hist. Soc.*, **29** : 748.
1933. *Ceriagrion olivaceium*, Fraser, *Fauna Brit. India*, Odonata, **1** : 324-326.

2 females "Tighra Dam, Gwalior, 2-x-53" and "Moti Jheel, Gwalior, 18-ix-53."

Prothorax dark brown; wings membranous unfumed white (fig. 31); 11 postnodal nervure in fore wing and 9 in hind wing. Abdomen olivaceous yellow upto fifth segment and dark olivaceous later on. Anal appendages brown.

This is common in many parts of India and Burma.

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

PART IX.—FIRST ANNOTATED CHECK-LIST OF INSECTS FROM THE NORTH-WEST (PUNJAB) HIMALAYAS

By M. S. MANI, SANTOKH SINGH, V. K. GUPTA and H. N. BAIJAL, *School of Entomology, St. John's College, Agra.*

In this check-list are included nearly 560 species of insects so far recorded from the Punjab Himalayas, between the Sutlej and Indus Valleys. Of these 23 species represent Odonata, 22 Orthoptera, 7 Dermaptera, 365 Coleoptera, 103 Hymenoptera, 9 Diptera, 4 Thysanura, 2 Aptera and 26 Collembola. References to the original descriptions and to the Fauna of India, where available, are included. In the notes on distribution attempt is made to include not only the localities within the area under survey (marked*) but also other records (given in square brackets). The remaining Orders and the additions to those already listed here will be included in subsequent check-lists. In addition to the abbreviations from the *World List of Scientific Periodicals*, the following are also employed; AMNH Annals and Magazine of Natural History, London; DEZ Deutsch. ent. Zeit; EMM Ent. monthly Mag; FBI Fauna British India; JBNHS Journal Bombay nat. Hist. Soc; Mission Babault for Mission dans les Provinces Centrales de'l'Inde et dans le Region Occidentale de l'Himalaya 1914 par Guy Babault; PZS Proc. zool. Soc. London; and RIM Rec. Indian Mus.

Order ODONATA

Family AESCHNIDAE

1. *Aeschna juncea* (Linn.), FBI, 3: 132 (1936)
   *Kashmir. [N. Europe; N. Asia; N. America.)
2. *Anaciaeschna kashmirense* Santokh Singh & Baijal, Agra Univ. J. Res., 3: 388 (1954).
   *Kashmir: Dal lake, Srinagar, 5000 ft.

Family AGRIIDAE

3. *Epallage fatima* (Charpentier), Lib. Eur., p. 132 (1840) (*Agrion*); FBI 2: 76 (1934)
   *Kashmir (?). [Amanus Mts. (Asia Minor); Wadi Kelt (Palestine); Quetta; Bagdad.]
4. *Rhinocypha trifasciata* Selys, Syn. Cal., p. 61 (1853); FBI, 2: 31 (1934). (Syn. *Libellago trifasciata* Walk.)
   *Kangra valley.

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*Contribution No. 62 from the School of Entomology, Agra. Part VIII of the Entomological Survey of the Himalayas was published in *Agra University J. Res.* (*Sci.*) (4) (1) : 187—208 (1955)

Family COENAGRIIDAE

5. *Enallagama cyathigerum* Charpentier, Lib. Eur., p. 163 (1840); FBI 1 : 373 (1933)
*Kashmir. [Central Asia, Tibet, Europe, British Isles, North America.]

6. *Ischnura inarmata* Calvert, Proc. Acad. Nat. Sci. Phil., p. 147, 148 (1898); FBI, 1: 357 (1933).
*Kashmir.

7. *Lestes barbara* (Fabr.), Suppl. Ent. Syst., p. 286 (1798), (*Agrion*); FBI, 1: 49 (1933)
*Kashmir: Yusimarg, 7500 ft. [N. W. India; Asia Minor; Algeria; S. Europe; France.]

8. *Lestes manaliensis*, Santokh Singh, Agra Univ., J. Res., 4 : 172 (1955).
*Manali, 6000 ft., Pir Panjal Range.

9. *Platycnemis latipes dealbata* Selys, Bull. Acad. Belg., (2) 16 : 167 (1863); FBI, 1 : 188 (1933).
*Kashmir. [N. W. India; Asia Minor; Egypt; Persia.]

10. *Sympycna paedisca annulata* Selys, Ann. Soc. Ent. Belg., 31 : 43 (1887); FBI, 1 : 85 (1933).
*Kashmir: Jhelum valley, 5000 ft, Srinagar. [N. W. India; Asia Minor; Mesopotamia; Persia; N. W. F. P; Quetta.]

Family CORDULEGASTERIDAE

11. *Allogaster parvistigma* (Selys), Bull. Acad. Belg., (2) 36 : 508 (1873) (*Thecogaster*); FBI, 3 : 41 (1936).
Himalayas [Bhaji, Simla Hills, 8800 ft. Apparantly rare below 9000 ft.]

12. *Cordulegaster brevistigma brevistigma* (Selys), Bull. Acad. Belg., (2) 21 : 103 (1854) (*Thecogaster*); FBI, 3 : 32 (1936). The Himalayas from *Kashmir to Assam.

Family GOMPHIDAE

13. *Ophiogomphus reductus* Calvert, Proc. Acad. Sci. Phil. p. 150, 152 (1898); FBI, 2 : 306 (1934)
*Kashmir : Gulmarg, 8500 ft, Yusimarg, 7500 ft.

Family LIBELLULIDAE

14. *Libellula quadrimaculata* Linn., Syst. Nat. ed. x: 543 (1758); FBI, 3: 315 (1936)
*Kashmir, Yusimarg & Gulmarg. [Tibet: Lhassa; Europe, Central & N. Asia; N. America; Japan.]

15. *Orthetrum brunneum brunneum* (Fonscol.), Ann. Ent. Soc. France, 6 : 141 (1827) (*Libellula*); FBI, 3: 294 (1936)

*Kashmir: Yusimarg & Gundarbal. [N. W. India; S. Europe; N. Africa; Asia Minor to Mesopotamia; Quetta.]

16. *Orthetrum cancellatum cancellatum* (Linn.) FBI, 3 : 302 (1936)
    *Kashmir: Gundarbal. (British Isle; Europe; N. Africa to Asia Minor.] (A palaearctic sp.)
17. *Orthetrum japonicum internum* MacLachlan, Ann. Mag. N. H., (6) 13 : 431 (1894); FBI, 3 : 304 (1936)
    *Kashmir. [Himalayan tracts of Bengal; Nepal; Tibet; S. W. China; Assam.]
18. *Orthetrum triangulare triangulare* (Selys), FBI, 3 : 305 (1936)
    *Kashmir. [Murree, Bengal to Burma (All along Himalayas) and hills of S. India above 5000 ft.]
19. *Selysiothemis nigra* (Van der Linden), FBI, 3 : 451 (1936)
    *Kashmir. [Sind: Karachi; Messopotamia; Persian Gulf; Markran coast to Sind.]
20. *Sympetrum commixtum* (Selys), Ann. Soc. Ent. Belg., 28 : 381 (1884) (*Diplax*); Agra Univ. J. Res., 3: 397 (1954)
    *Kashmir : Yusimarg, Gulmarg, 8700 ft. [N. W. India; Abottabad.]
21. *Sympetrum fonscolombei* (Selys). Mon. Lib. Eur. 1840 (*Libellula*); FBI, 3 : 377 (1936)
    *Kashmir. [N. W. Provinces; South Indian Hills; British Isles; Africa; C. Asia.]
22. *Sympetrum meridionale* (Selys), FBI, 3: 376 (1936)
    *Kashmir: Yusimarg, 7500 ft, Gulmarg, 8000 ft. [S. Europe, N. Africa Asia Minor to Persia.]
23. *Sympetrum tandicola*, Santokh Singh, Agra Univ. J. Res., 4 : 171 (1955)
    *Upper Chenab Valley, near Tandi, 11,000 ft.

Order ORTHOPTERA

Family ACRIDIDAE

1. *Acrida exaltata* (Walk.), Ann. Nat. Hist., 3 (3) 4 : 222 (1859) (*Truxalis*); FBI, p. 99 (1914); Mission Babault, p. 10 (1925)
   *Kangra : Bajaura. [Ceylon.]
2. *Acrida lugubris* Burr., Trans. ent. Soc. London, 157, 170 (1902) FBI, p. 99 (1914).
   *Kashmir: Hanza. [Madras.]
3. *Aularches punctatus* (Drury) Ill. Exot. Ent. 2, pl. xli, fig. 4 (1773); FBI, p. 169. fig. 112 (1914).
   *Kashmir. [Tibet; Nepal; Garhwal; Malaya; Java.]
4. *Bryodema luctuosa* (Stoll) Reprĕs. Spectrés, Mant., Sautér. etc. p. 24 (*Gryllus*); Mission Babault, p. 15 (1925)
   *Rupshu: Tsho-Moran,

5. *Caloptenopsis liturifer* (Walker), Cat. Derm. Salt. B. M. 4 : 703. (1870) (*Caloptenus*); FBI, p. 259 (1914).
   *Kashmir: Baltistan. [Madura.]
6. *Catantops humilis* (Serville), Ins. Orth. 662 (1839); FBI, p. 250 (1914); Mission Babault, p. 30 (1925) (*C. innotabilis*)
   *Spiti: Gharry. [Assam; Sikkim; Calcutta; Bombay; Ceylon]
7. *Crotogonus incertus* Bol., Ann. Soc. Esp., 13 : 45 : FBI, p. 163 (1914); Mission Babault, p. 28 (1925).
   *Kangra: Bajaura. [Assam; China.]
8. *Dicranophyma babaulti* Uvarov, Mission Babault, p. 31 (1925)
   *Kashmir: Gond.
9. *Gasterimargus transversus* (Thunb.), Mem. Acad. Petersb., p. 233 (1815); FBI, p. 145 (1914)
   *Kashmir: Baltistan. [Nepal; Garhwal; Assam; Bengal; Madras; Java; Celebes.]
10. *Gomphomastax antennatus* Brunner, Abh. Senik. Ges., 24 : 232 (1818); FBI: 93 (1914)
   *Kashmir.
11. *Gomphomastax* sp. Mission Babault, p. 9 (1925)
   *Rupshu : Tsho Morari.
12. *Oedipoda himalayana* Uvarov, Mission Babault, p. 22 (1925)
   *Kashmir: Doyen, 8000 ft; *Ladak: Mulbeck.
13. *Oxya velox* (Fabricius) Mant. Ins., 2 : 239 (1787); FBI, p. 199 (1914)
   *Kashmir: Baltistan. [Assam; Bombay; Madras; Ceylon; China; Malaya; Java.]
14. *Patanga succinata* (L.) Amoen. Acad., 4 : 398; FBI, p. 227 (1914); Mission Babault, p. 31 (1925)
   *Kangra: Bajaura. [Ceylon; China; Sumatra; Java; Borneo; and whole of India.]
15. *Sphingonotus balteatus* Serville, Ins. Orth. 1839, p. 334; FBI, p. 157 (1914).
   *Kashmir: Baltistan. [Bombay].
16. *Sphingonotus kashmirensis* Uvarov, Mission Babault, p. 18 (1925).
   *Kashmir : Baltal.
17. *Sphingonotus longipennis* Sauss., Mem. Soc. Genev, 28 (9) : 197 (1884); FBI, p. 156 (1914); Mission Babault, p. 17 (1925)
   *Bajaura (Kangra); Malakand. [Assam.]
18. *Sphingonotus rubescens* (Walk.), Zoologist, (2) 5: 2301; FBI, p. 155 (1914); Mission Babault, p. 16 (1925)
   *Ladak : Leh. [Baluchistan ; Arabia; Egypt; Greece; Sardinia.]
19. *Sphingonotus savingnyi* Sauss., Mem. Soc. Geneve, 28 (9) : 198, 208 (1884); FBI, p. 155 (1914)
   *Ladak. [Sind; C & W. India; N. Africa.]

20. *Stauroderus biguttulus* (Linné), Syst. Nat. (ed. x): 443. Mission Babault, p. 11 (1925)
*Kangra : Bajaura.

21. *Stauroderus vagans* (Evers.)? Addit. Fisch. Waldh. Orth. Ross., p. 12; Mission Babault, p. 12 (1925)
*Bajaura (Kangra)

22. *Stenobothrus luteipes* Walk., Cat. Derm. Salt. B. M., Supp, (1871) p. 82; FBI, p. 121 (1914)
*Kashmir: Baltistan.

Order DERMAPTERA

Family FORFICULIDAE

1. *Anechura calciatii* Borelli, Bull. Nus. Tor. 24 (603) : 1-4 (1909); FBI, p. 159 (1910)
*N. E. Kashmir, road from Srinagar to Gilgit, 8000 ft.

2. *Anechura bipunctata pirpanjalae* Santokh Singh, Agra Univ. J. Res., 4 (1) : 182 (1955)
*Khoksar, 12000 ft. Upper Chenab Valley.

3. *Anechura himalayana* Santokh Singh, Agra Univ. J. Res., 4 (1) : 180 (1955).
*Khoksar, 12000 ft, Upper Chenab Valley.

4. *Anechura zubovskii* Semenov, Horae Soc. Ent. Ross., 35 : 185 (1901); FBI, p. 160 (1910).
*Kashmir, Ladak Valley, road from Srinagar to Gilgit.

5. *Himanechura lahaulensis* Santokh Singh, Agra Univ. J. Res., 4 (1) : 184 (1955)
*Khoksar, 12000 ft., Upper Chenab Valley.

Family LABIDURIDAE

6. *Forcipula pugnax* (Kirby), Linn. Soc. J. Zool., 23 : 502-515 (1891); FBI, p. 93.
*Kangra Valley

7. *seudisolabis burri* Borelli, Boll. Mus. Tor., 24 (603) : 1-4 (1909); FBI, p. 103 (1910).
*N. E. Kashmir, on road from Srinagar to Gilgit, 6700 ft.

Order COLEOPTERA

Family CARABIDAE

1. *Abacetus guttula* Chaud., Mon., 374; Mission Babault, p. 45 (1924)
*Spiti: Manikarn; *Kangra: Bajaura; *Kulu: Manali, Kandi, Koty.

2. *Acinopus novorossicus* Sem., Hor. Soc. Ent. Ross., 32 : 604, 609 (1899); Mission Babault, p. 31 (1924)
*Kashmir: Sind Valley, Sonemarg, Gond.

3. *Amara aenea* (Geer), Mém. Ins., 4 : 98 (1774) (*Carabus*); Mission Babault, p. 42 (1924).
   *Kangra: Bajaura.
4. *Amara bamidunyae* Bates, PZS, p. 716 (1878); Mission Babault, p. 43 (1924)
   *Spiti: Pulga; *Kulu : Koty.
5. *Amara tiruka* Andrewes, Mission Babault, p. 97 (1924)
   *Kashmir : Sonemarg; * Ladak : Leh.
6. *Amara lamia* Andrewes, Mission Babault, p. 99 (1924)
   *Ladak : Leh; * Rupshu : Tsho-Morari.
7. *Amara nila* Andrewes, Mission Babault, p. 96 (1924) *Spiti: Manikarn, Pulga, Tchary-Djoni, Tsho-ti;
   *Kulu: Kandi, Koty; *Kangra : Bajaura; *Chamba.
8. *Anchomenus benardi* Andrewes, Mission Babault, p. 102 (1924).
   *Lahaul : Gondla, Kyelang, Sisu; *Spiti: Pulga, Tchary-Djoni, Manikaran; *Kulu: Koty.
9. *Anchomenus caesitius* Andrewes, Mission Babault, p. 104 (1924) .
   *Lahaul : Sisu, Somdéo; *Kulu : Kandi, Koty.
10. *Anchomenus eurous* Andrewes, Mission Babault, p. 105 (1924)
    *Spiti : Pulga; *Kulu: Kan di,Koty.
11. *Anchomenus ladakensis* Bates, PZS p. 718 (1878); Mission Babault, p. 48 (1924).
    *Ladak : Leh.
12. *Anchomenus lissopterus* Chaud., Bull., Mosc.,1 : 136 (1854) Mission Babault, p. 49 (1924).
    *Spiti: Pulga; *Kulu : Mandi, Koty.
13. *Asaphidion championi* Andrewes, Mission Babault, p. 84 (1924); FBI, 2 (1) : 84, pl. 4 fig. 8 (1935)
    *Spiti : Manikarn: [Simla Hills 3600-4000 ft; Kumaon; Garhwal; Kalimpong; Assam: Darrang; Doiphang Valley.]
14. *Asaphidion indicum* Chaud., Bull. Soc. Imp. Moscou, 2: 189 (1850); FBI, 2 (1) : 88, pl. v, fig. 5 (1935).
    *Dharamsala; *Mandi. [Simla; Kumaon; Garhwal; Darjiling; Kurseong.]
15. *Axomya championi* Andrewes, AMNH, (9) 12 : 680. pl. ii. fig. 5, 5a, 5b. (1925); Mission Babault, p. 22 (1924)
    *Bajaura (Kangra).
16. *Bembidion ajmonis* Netolitzky, Att. mus., civ. Trieste, 12 : 95, pl. xi. (1934); FBI, 2 (1) : 132 (1935)
    *Kashmir : Razdhainangan, 11, 500 ft.
17. *Bembidion algidum* Andrewes, FBI, 2 (1) : 187, fig. 29 (1935)
    *Kashmir : Gulmarg, 8000-9000 ft, Khilanmarg, 11000 ft.
18. *Bembidion aquilum* Andrewes, Mission Babault, p. 76, pl. i, fig. 6 (1924); FBI, 2 (1) : 126 (1935)
    *Lahaul: Patséo; *Kashmir : Gund, Baltal; *Ladak: Leh, Mulbeck; Gulmarg; Skardu.

19. *Bembidion atalanta* Andrewes, FBI, 2 (1) : 178 (1935)
 *Kashmir : Lianmarg, 10000 ft.
20. *Bembidion babaulti* Andrewes, Mission Babault, p. 80. pl. i, fig. 7 (1924); FBI, 2 (1) : 176 (1935)
 *Kashmir : Jhelum Valley, Garhi, 4000 ft. *Kulu : Mandi; *Kangra Valley. [Jammu : Batote; Simla; Dehra Dun; Mussurie; China. (2000-9000 ft. common)]
21. *Bembidion betegara* Andrewes, Mission Babault, p. 82 (1924) ; FBI, 2 (1) : 148 (1935).
 *Spiti : Pulga; *Kulu: Koty, Mandi. [Simla: Bahsahr; Sangla 8000 ft.]
22. *Bembidion bracculatum* Bates, PZS, 212 (1889); FBI, 2 (1) : 146 (1935).
 *Kashmir: Sakardu, Matayan, 10000 ft. [U. P. Kumaon: Gori river gorge, 5000-9000 ft; Laptel 15000 ft; Milam in Gori valley 11,500ft.]
23. *Bembidion bucephalum* Neotolitzky, Ent. Mitt., 9 : 63, 114 (1920); FBI, 2 (1) : 118 (1935).
 *Kashmir : Chhota Deosai 13000 ft, Indus valley : Boorgi Nala 12000 ft, Braldo Valley, Kro Brok, 12400 ft. Thla Brok 14000 ft, Punmah Valley, Dumiltar 14000 ft. Baltoro, Urdukas 13400 ft, Mundu. [Turkestan; Bokhara; Transcaspia).
24. *Bembidion cameroni* Andrewes, Ent. Mon. Mag., p. 177 (1922) FBI, 2 (1) : 111 (1935).
 *Kulu: Manali, 6000 ft. [Simla Hills, Gahan 7000 ft; Assam; Gori River Gorge (U. P.); China.]
25. *Bembidion caporiaccoi* Netoletzky Att. Mus. Civ. Trieste, 12 : 99 (1934); FBI, 2 (1) : 204. (1935).
 *Kashmir: Sind Valley, Kangan, 6500 ft., Indus Valley, Olthingthang, 8600 ft, Shigar Valley, Alchori, Kushumul, all about 7500 ft, Braldo Valley, Askole and Biaho, about 10,000 ft.
26. *Bemibidion clops* Andrewes, FBI, 2 (1) : 174 (1935)
 *Kashmir : Jhelum Valley, Buniyar 5000 ft.
27. *Bembidion dux* Andrewes, FBI, 2 (1) : 130, (1935) .
 *Kulu : Parbati Valley, 6000-8000 ft. [Kumaon : Gori River Gorge, 5000-9000 ft.]
28. *Bembidion eupages* Andrewes, Mem. Conn. Acad., 10 : 25, 27 (1934); FBI, 2 (1) : 190, fig. 30 (1935).
 *Kashmir : Lakut, Dal Lake, 5200 ft., Phashakwii near Pampur, 5200 ft.
29. *Bembidion eutherum* Anderewes, Ent. Mon. Mag., p. 16 (1923); FBI, 2 (1) : 139 (1935).
 *Kangra, 4000 ft. [Simla Hills, Garhwal; Kumaon; E. Duars; Sikkim; Assam 4000 ft.]
30. *Bembidion exaratum* Andrewes, Mission Babault, p. 81 (1924).
 *Spiti: Mankaran. [Simla Hills 7000 ft.]
 *Kashmir 5000 ft., [Chakrata 8000 ft; W. Almora; Bengal.]

31. *Bembidion fuscicrus* Motschusky, Mission Babault, p. 16, (1924); FBI, 2 (1): 178 (138 (1935).
*Kashmir : Baltal; *Leh : Mulbeck, Nuria (Ladak); Salt Lake, Tso-Morari, Nima-Mud (Rupshu).

32. *Bembidion fuscicrus* (Fald.), Mus., Acad. St. Pétersh, p. 357, (1835); Mission Babault, p. 16 (1924).
*Ladak : Leh, Mulbeck, Nuria; * Kashmir : Baltal; Rupshu; Lac Sale, Tsho-Morari, Nima-Mud.

33. *Bembidion gagates* Andrewes, Mission Babault, p. 68, pl. i,
*Kashmir : Gond, 10,000 ft; *Spiti: Mankarn, Pulga, *Lahaul: Kyelang, Patséo, Sumdeo; *Kulu: Koty; *Kangra : Bajaura. [Not east of Kumaon. Common in N. W. Himalayas.]

34. *Bembidion gilgiti* Andrewes, FBI, 2 (1) : 171 (1935)
*Gilgit 5000 ft.

35. *Bembidion hasurada* Andrewes, Mission Babault, p. 77 (1924); FBI, 2 (1): 138 (1935).
*Gulmarg, 6500 ft, Apharwat 13,000 ft. Kangan; *Ladak: Mulbeck; *Spiti: Pulga, Batote; Chenab Valley: Raman; *Kulu. [Simla Hills; W. Almora; Chakrata, 7000 ft-8300 ft.]

36. *Bembidion himalayanum* Andrewes, Mission Babault, p. 74 (1924); FBI, 2 (1) : 119 (1935).
*Lahaul : Patséo; *Kangra : Baijnath; *Dharmsala: Triund, 9300 ft; Jalori Pass, 10800 ft. [Kurram Valley; Tibet.]

37. *Bembidion holconotum* Andrewes, FBI, 2 (1) : 138 (1935)
*Kashmir : Batote. [Mussurie, 7500 ft.]

38. *Bembidion hutchinsoni* Andrewes, Mem. Conn. Acad., 10 : 24, 26 (1934); FBI, 2 (1) : 162 (1935)
*Kashmir : Kiam, 15, 630 ft. (Edge of hot spring).

39. *Bembidion irregulare* Netolitzky, Att. Mus., Civ. Trieste, 12 : 90 (1934); FBI, 2 (1) : 136 (1935) .
*Kashmir : Gond, 8000 ft, Shaksgan Valley 13000 ft. (Tarim basin) 15000 ft.

40. *Bembidion ixion* Andrewes, Mem. Conn. Acad., 10 : 24 (1934) FBI, 2 (1) : 166 (1935) .
*Kashmir : Matyan, 10,000 ft.

41. *Bembidion kasehmirense* Netolitzky, Ent. Mitt., p. 117 (1920) ; FBI, 2 (1): 130 (1935).
*Bashahr : Poo.

42. *Bembidion ladakense* Andrewes, Mission Babault, p. 17 (1924); FBI, 2 (1) : 167 (1935)
*Ladak : Mulbeck; * Kashmir : Gond, Baltal; * Lahoul: Sumdeo, Khalatse; Biaho Valley, Bardumal, 11000 ft.

43. *Bembidion ladas* Andrewes, Mission Babault, p. 79, pl. i, fig. 5 (1924); FBI, 2 (1) : 165, pl. iv. 3 (1935)

*Rupshu : Nima-Mud, *Tsho-Morari, Salt lake;
*Ladak : Leh, Mulbeck, Rango.

44. *Bembidion leve*, Andrewes, Mission Babault, p. 78, (1924); FBI, 2 (1) : 135 (1935).
*Ladak : Mulbeck.

45. *Bembidion limatum* Andrewes, Mission Babault, p. 77 (1924) : FBI, 2 (1) : 135 (1935)
*Kangra : Bajaura.

46. *Bembidion lissonotum* Andrewes, FBI, 2 (1) : 192, fig. 31 (1935) .
*Kashmir: Lolab Valley, Nagmarg, 7500 ft.

47. *Bembidion livens* Andrewes, Trans. ent. Soc. London, p. 3, 11 (1930); FBI, 2 (1) : 131 (1935).
*Kashmir. [Tibet, 10,000 ft—12,000 ft.]

48. *Bembidion luntaka* Andrewes, Mission Babault, p. 75 (1924); FBI, 2 (1) : 171 (1935).
*Suru Basin; Shimsha Karboo; Parkutta; Tolti, Golskardu; *Ladak: Leh, Mulbeck, Nuria; *Kashmir: Baltal, Sonemarg; *Kulu : Koty; *Rupshu: Nima-Mud; *Lahoul: Kyelang, Sumdéo, Sisu, Zingzingbar. *Indus Valley : Olthingthang, Mashung, Parkutta, Tolti; *Shigar Valley : Shigar, Juno, Alchori, Kushumul.

49. *Bembidion manicatum* Andrewes, FBI, 2 (1) : 152 (1935)
*Kashmir, Lidar Valley, *Lidarwat, 9000 ft.

50. *Bembidion ochropus* Andrewes, FBI, 2 (1) : 137 (1935)
*Kashmir : Poo

51. *Bembidion orinum* Andrewes, Ent. Mon. Mag., p. 239 (1922) FBI, 2 (1): 129, pl. iv, fig. 4 (1935).
*Kulu : Parbati Valley, 6000-8000 ft. [W. Almora, Gori Valley, 5000-9000 ft; Burphu 11,500 ft.]

52. *Bembidion nivicola* Andrewes, AMNH (9) 11 : 275 (1923) FBI, 2 (1) : 121 (1935)
*Kashmir : Daulad Begaldi near Karakorum Pass, 16500 ft. [Tibet, Mt. Everest Base Camp, Rombug 16, 500 ft.]

53. *Bembidion pamiricola* Lutchnik, Abh. Pamir. Exped. 1928, 2 : 34, pl. i, fig. 1 (1930); FBI, 2 (1) : 166 (1935)
*Kashmir : Biaho Valley, Bardumal, 11000 ft. [Pamirs.]

54. *Bembidion petrimagni* Netolitzky, Ent. Mitt., p. 113 (1920); FBI, 2 (1) : 119 (1935).
*Kashmir : Deosai, Lal Pani, 13,000 ft., Baltoro, Widukus, 14,200 ft. [Pamirs.]

55. *Bembidion pluto* Andrewes, Mission Babault, p. 72 (1924) FBI, 2 (1) : 123, pl. iv, fig. 1 (1935).
*Rupshu : Nima-Mud, Tsho-Morari, Salt Lake; *Ladak: Leh. [Tangyar, 14,300 ft., Lukung, 14,000ft., Igu, 12,000 ft., Kumaon.]

56. *Bembidion psitodorum* Andrewes, AMNH, (10) 11 : 412 (1933); FBI, 2 (1) : 180 (1935) .
    *Kashmir: Lidar Valley, Pahalgam, 7000 ft, Frislina, 8000 ft, Lidarwat, 9000 ft, Gulmarg, 8500 ft.
57. *Bembidion regale* Andrewes, Ent. Mon. Mag., 174 (1922) FBI, 2 (1) : 129, iii, 8. (1935).
    *Dharamsala. [Gori River Gorge (U. P.)]
58. *Bembidion rubidum* Andrewes, Ent. Mon. Mag., 196 (1924); FBI, 2 (1) : 173 (1935).
    *Kashmir : Bumiyar, 5000 ft. [Bashahr: Poo.]
59. *Bembidion satanas* Andrewes, Ent. Mon. Mag., p. 193 (1924); FBI, 2 (1) : 127 (1935).
    *Kashmir : Goorais Valley, 7000 ft, Gulmarg, 8500 ft, Lidar Valley, 9000 ft., Gund 7000 ft., Kolahoi, 11,000 ft. [Chitral.]
60. *Bembidion sillemi* Netolitzky, Att. Mus., Civ. Trieste, 12 : 92 (1934); FBI, 2 (1) : 175 (1935).
    *Kashmir : Srinagar, Sind Valley, Kangan, Gund.
61. *Bembidion surdum* Andrewes, FBI, 2 (1) : 145 (1935)
    *Kashmir : Batote. [Chakrata, 7850 ft.]
62. *Bembidion uvidum* Andrewes, Mission Babault, p. 83 (1924) : FBI, 2 (1) : 160 (1935).
    *Kangra : Bajaura. [Nainital, Ranikhet.]
63. *Bembidion varium* Otiv, Encycl mith., 5 : 358 (1790); FBI, 2 (1) : 195 (1935)
    *Kashmir: Jhelum Valley, 5000 ft., Lokut Dal Lake, 5200 ft. [Persia; Europe; N. Asia, N. Africa.]
64. *Bembidion xostum* Andrewes, Ent. Mon. Mag. 97 (1923); FBI, 2 (1) : 149 (1935).
    *Kulu; Kasol, 6000 ft. [Nainital.]
65. *Brachynus stenoderus* Bates, Trans. Ent. Soc. London, p. 305 (1873). Mission Babault, p. 57 (1924)
    *Kangra : Bajaura.
66. *Brachynus stevensi* Andrewes, Mission Babault, p. 107, pl. iv, fig. 2, (1924).
    *Kangra : Bajaura.
67. *Bradytus compactus* Bates, PZS, p. 717 (1878). Mission Babault, p. 42 (1924).
    *Spiti : Pulga; * Kulu : Koty.
68. *Broscus punctatus* Dej., Spec. Gén., 3 : 451 (1828); Mission Babault, p. 20 (1924)
    *Spiti: Manikarn; Kangra : Bajaura.
69. *Calathus clarus* Andrewes, Mission Babault, p. 101, p. 13, fig. 4 (1924).
    *Spiti : Pulga; *Kulu : Kandy, Koty.
70. *Calathus himalayae* Bates, Entom, suppl. 9 (1891); Mission Babault, p. 47 (1924).
    *Kulu: Koty, Valley Rotang.

71. *Calathus kollari* Putz, Ann. Soc. Ent. Belg., p. 72 (1973); Mission Babault, p. 46 (1924).
*Lahoul : Sumdéo; *Spiti : Pulga, Manikarn, Mankarn, Tajary-Djoni; *Kangra : Bajaura; *Kulu: Koty, Kandi; *Kashmir : Baltal.

72. *Callistomimus coarcatatus* (Laf.), Ann. Soc. Ent. France, 230 (1851) (*Callistus*). Mission Babault, p. 23 (1924).
*Spiti : Manikarn

73. *Calosoma auropunctatum* (Herbst.), Fuessly's Archiv, 131, (1784) (*Carabus*). Mission Babault, p. 6 (1924)
*Lahoul : Sumdéo, Patséo, Sisu, Kyelang, Rotang Valley.

74. *Calosoma beesoni* Andr., AMNH (9) 4 : (1919). FBI, 1 : 52 (1929).
N. W. Himalayas. [U. P. Mondali, Kathian, Molta, Bodyar, all Jaunsar Himalayas, 7500-8000 ft; Thano, Dehra Dun, 4000 ft; Punjab: Simla division.]

75. *Calosoma himalayanum* Gestro, Ann. Mus., Civ. Gen, 7 : 851 (1875); FBI, 1 : 55 (1929).
*Kashmir ; *Ladak, Sind division, Mosashel range, Haran plantation; *Punjab : Chamba. [Khalatse, 4500 ft, Bashahr, Poo].

76. *Calosoma maderae auropunctatum* (Herbst), in Arch. Ins-Gesch., 5: 131 (1784); FBI, 1 : 58 (1929)
*Kulu; *Lahoul : Sumdeo, Patséo, Sisu, Kyelang, Cinuir; Rotang Valley ; *Chamba; *Kashmir : Sonemarg, 8600 ft, Kogyar, Sind Valley; *Ladak : Dras, Kargil, Leh.

77. *Calosoma maderae indicum* Hope, Zool. Misc., 21 (1831) ; Mission Babault, p. 6 (1928); FBI, 1 : 61, fig. 10 (1929)
*Spiti : Pulga, Tshoti, Manikarn ; *Kashmir : Gond, Srinagar. [N. W. F. P., Peshawar, Taru ; Kohat; Bengal: Calcutta ; Bihar : Pusa, Chapra; U. P. : Dehra Dun.]

78. *Calosoma maderae kashmirense* Breun., Mon (1) : 216; FBI, 1 : 60 (1929).
*Kulu : Rotang Valley ; *Lahoul : Sumdeo ; *Kashmir; [Tibet.]

79. *Carabus barysomus* (Bates), PZS, p. 210 (1889); FBI, 1 : 87, fig. 14 (1929).
*Kashmir : Gurais Valley, Pir Panjal, Batote, 8000-10000 [N. W. F. P. Hazara, Lower Kagan Valley; Shran, 8000 ft.]

80. *Carabus barysomus heroicus*, Sem., Rev. Russ. Ent. p. 395 (1906); FBI, 1: 90, fig. 15 (1929)
*Kashmir : Mountains west of Pir Panjal and north of Punch.

81. *Carabus barysomus hügeli* Roesch., Deutsch. Ent. Zeitschr. p. 547, (1907); FBI, 1 : 90 (1929)
*Kashmir : Mountain north-east of Islamabad.

82. *Carabus boysi* Tatum, AMNH, (2) 8 : 51 (1851); Mission Babault, p. 7 (1924); FBI, 1 : 95 (1929).
*Kashmir : Sonemarg; *Kulu : Kandi; *Chamba; *Spiti: Pulga, Tchary-Djoni, Tsho-ti. [Simla; Bashahar; Garhwal Mundali; Beoban Bodyar; west Almora ; Dudhatoli and Sunderdhumga Valley.]

83. *Carabus caschmirensis* Redt., in Hugel's Kaschmir, 4 (2) : 499 (1844); FBI, 1 : 91, fig. 16 (1929).
*Kashmir, mountains west of Pir Panjal and north of Punch, 5000-6000 ft; *Kulu. [Murree; Simla; Nainital; Mussurie; Chakrata; Kathian; Binsar, 6000 ft; Kanasar, 7050 ft; Jaunsar Himalaya, 7000 ft.]

84. *Carabus dardiellus* Bates, PZS, p. 211 (1889); FBI, 1 : 97 (1929)
*Kashmir : Guriar Valley, Radjawar, Songam, Susu, South east of Islamabad, Batote, Gulmarg, Nagmarg.

85. *Carabus cardiellus granulispersus* Bates, PZS, p. 211 (1889); FBI, 1 : 99 (1929).
*Kashmir : Gurais Valley, Pir Panjal, south west of Srinagar, 8000-10000 ft., Jhelum Valley, Gulmarg, 85000 ft.

86. *Carabus dardiellus klägeri* Kraatz, Deutsch. Ent. Zeitschr., p. 558 (1907); FBI, 1 : 98 (1929)
*Kashmir : Radjawar, Pir Panjal, south west of Srinagar, 6000-8000 ft.

87. *Carabus dardiellus subpunctulus*, Roesch. Deutsch. Ent. Zeitschr., p; 558 (1907); FBI, 1 : 98 (1929) .
*Kashmir Mountains N. E. of Islamabad, 6000-8000 ft.

88. *Carabus epipleuralis* Semenov, Rev. Russ. Ent., p. 286 (1906) FBI, 1 : 96 (1929).
*Kashmir : Mountains west of Pir Panjal and North of Punch, 6000-10000 ft.

89. *Carabus rostianus* Semenov, Rev. Russ. Ent. p. 267 (1906); FBI, 1 : 93 (1929).
*Kashmir : North-East of Islamabad, 5000-6000 ft, Songam, Dusu, south east of Islamabad, 6000-10000 ft., Lidar Valley, Tanin, 9000 ft.

90. *Carabus stoliczkanus* Bates, PZS, p. 713 (1878) ; FBI, 1 : 94 (1929).
*Kashmir : Mountains West of Pir Panjal, 6000-10,000 ft. [Murree; Campbellpore.]

91. *Chaetobroscus anomalus* (Chaud), Bull. Mosc., 3 : 1 (1878) (*Broscus*); Mission Babault, p. 21 (1924), pl. 2 fig. 3; FBI, 2 (1) : 43 (1934).
*Lahoul, Sisu; *Spiti : Pulga, Rotang Valley; Sishramnag, 12,000 ft, Kilanmarg, 10,0000 ft. Lidarwat, 9000 ft. Seraj : Jalori Pass 10,000 ft, Tragbul Pass: Gilgit Road 10,800 ft.

92. *Chlaenius agilis* Chaud., Bull. Mosc., 3 : 246 (1856) Mission Babault, p. 26 (1924)
*Kangra: Bajaura.

93. *Chlaenius caeruleus* (Stév), Mém. Soc. Nat. Mosc., 2 : 38 (1809); Mission Babault, p. 27 (1924)
*Ladak : Mulbeck.

94. *Chlaenius circumdatus* Brullé, Silb, Rev. Ent. 3 : 283 (1835); Mission Babault, p. 25 (1924)
*Kangra : Bajaura.

95. *Chlaenius hamifer* Chaud., Bull. Mosc., 3 : 209 (1856); Mission Babault, p. 24 (1924).
*Kashmir : Sonemarg.

96. *Chlaenius kuluensis* Bates, Entom, suppl. 9 (1891); Mission Babault, p. 27 (1924).
*Kulu : Koty; *Kashmir : Sonemarg.

97. *Chlaenius laetiusculus* Chaud, Bull. Mosc., 3 : 248 (1856); Mission Babault, p. 28 (1924) .
*Kangra : Bajaura.

98. *Chlaenius pictus* Chaud., Bull. Mosc., 3 : 208 (1856); Mission Babault, p. 24 (1924)
Kangra : Bajaura.

99. *Chlaenius punctatostriatus* Chaud., Bull. Mosc., 3 : 244 (1856); Mission Babault, p. 25 (1924).
*Kangra : Bajaura.

100. *Chlaenius tenuelimbatus* Ball., Bull. Mosc., 4 : 326 (1870) Mission p. 27 (1924).
*Ladak : Leh.

101. *Chydaeus bedeli* (Tchitch), L'Abeille, 29 : 66 (1897) Mission Babault, p. 29 (1924)
*Spiti : Pulga; *Kulu : Kandi, Koty.

102. *Coelostomus picipes* Magleay, Ann. Jav. p. 24, (1825) Mission Babault, p. 44 (1924).
*Kangra : Bajaura.

103. *Craspedontus himalayanus* Sem., Rev. Russ. Ent., p. 216 (1910) Mission Babault, p. 21 (1924) , pl. 2, fig. 4; FBI, 2 (1); p. 39, pl. iv, fig. 10 (1935).
*Kangra : Bajaura; *Kulu 5000-7000 ft. Parbati Valley 7000 ft. [Chitral : Lect-Koh Valley.]

104. *Cyclosomus suturalis* (Wied.), Zool. Mag. 1 (3): 169 (1819) (*Scolytys*); Mission Babault, p. 62 (1924)
*Kangra : Bajaura.

105. *Cymindis babaulti* Andr., Mission Babault, p. 113, pl. iv, fig. 6 (1924).
*Ladak : Leh.

106. *Cymindis glabrella* Bates, 2nd Yark. Mission, 20, t. 1, fig. 17, (1891) Mission Babault, p. 64 (1924)
*Kashmir : Baltal; *Ladak.

107. *Cymindis mannerheimi* Gebl., Bull. Acad. St. Petr., 1: 36 (1843); Mission Babault, p. 64 (1924)
*Kashmir : Baltal; Ladak : Mulbeck, Tarbagatai, Moutagnes, Issyk-kul [Pamir] Pangong Valley.

108. *Drypta lineola* Macleay, Ann. Jav., p. 27 (1825); Mission Babault, p. 52 (1924).
*Spiti : Manikarn.

109. *Harpalus amarellus* Bates, Entom. suppl. 10 (1891); Mission Babault, p. 37 (1924)
*Kangra: Bajaura, Mandi, Naggar : Kulu; Cimur, Kyelang, Sumdeo, Sisu : Lahoul.

110. *Harpalus melaneus* Bates, PZS, p. 714 (1878); Mission Babault, p. 36 (1924).
*Kashmir : Baltal, Sonemarg; Valley Rotang; Kulu : Koty; Spiti: Pulga; *Lahoul: Zingzingbar, Sumdéo, Patséo, Sisu, Kyelang, Gondla, Cimur.

111. *Harpalus quadricollis* (Redt.), Hügel's Kashmir, 4 (2) : 502 (1844) (*Selenophorus*); Mission Babault p. 37 (1924)
*Lahoul: Sisu, Zingzingbar,, Pastéo, Sumdéo, Kyelang; *Spiti : Pulga; Kashmir : Baltal.

112. *Hypsinephus ellipticus* Bates, PZS, p. 716 (1878); Mission Babault, p. 36 (1924).
*Kashmir : Baltal.

113. *Kareya edentata* (Bates), Ann. Mus. Civ. Gen., p. 331 (1892); Mission Babault, p. 32 (1924)
*Kangra : Bajaura.

114. *Leistus kashmirensis* Andr., Eos, 3 : 65 fig. 1 (1927) ; FBI, 1 : 110 (1929).
*Kashmir: Sintan Pass.

115. *Leistus nivium* Andr., AMNH, (9) 15 : 312 (1925); FBI, 1 : 108 (1929).
*Kashmir : Dusu, Sintan Pass.

116. *Liocnemis himalaica* Bates, PZS, p. 716 (1878); Mission Babault, p. 43 (1924).
*Lahoul : Sumdeo; *Kashmir : Sonemarg.

117. *Mastax annulatus* Andr., Mission Babault, p. 111 (1924).
*Spiti : Manikarn.

118. *Mastax laeviceps* Bates, Compt. rend. Soc. Ent. Belg., p. 337 (1891); Mission Babault, p. 58 (1924)
*Spiti : Manikaran.

119. *Mastax vegetus* Andr., Mission Babault, p. 110. pl. iv, fig. 5 (1924)
*Kangra : Bajaura.

120. *Metabletus fuscomaculatus* Motch. Motch. Ins. Sib. p. 59 (1844); Mission Babault, p. 65 (1924)
*Chamba

121. *Metabletus lartarus* Bates, PZS., p. 719 (1878); Mission Babault, p. 64 (1924).
*Lahoul : Patséo.

122. *Nebria babaulti* Andr., Mission Babault, p. 67, pl. i, fig. 1, (1924)
*Kashmir : Baltal; *Ladak : Mulbeck.

123. *Nebria barbata* Andr., FBI, 1 : 130 (1929).
*Kashmir

124. *Nebria himalayica* Bates, PZS, p. 212 (1889); FBI, 1 : 125 (1929)
*Kashmir: Gurais Valley, Skardo; *Kulu, Parbati Valley [Bashahar State, Poo. Almora, Milam in Gori Valley 11, 500 ft, Chakrata Division, Khedar Khund.]

125. *Nebria limbigera* Solsky, Zool Col., 1 : 13 (1874); Mission Babault, p. 5 (1924); FBI, 1 : 120 (1929)
*Rupshu : Tsho-Morari, Nima-Mud; *Lahoul: Zingzingbar: *Ladak : Mulbeck, Kargil. [Kumaon, Turkestan : Kokand; Alai mountains; Pamir; China; Monpin.]

126. *Nebria limbigera babaulti* Andr. Mission Babault, p. 67, pl. 1, fig. 1 (1924); FBI, 1 : 121 (1929)
*Kashmir : Baltal, Mulbeck.

127. *Nebria masrina* Andr., Mission Babault, p. 68 (1924) FBI, 1 : 128 (1929).
*Kashmir: Baltal.

128. *Nebria psammophila* Solsky, in Fedchinko's Turkéstan, 2 (5) : 12 (1874); FBI, 1 : 118 (1929).
*Kashmir : Kargil, Sonemarg, 8600 ft., Ganderbal, 5500 ft., Achibal, 5600 ft., Jhelum Valley, 5000 ft. [Turkestan: Kokand, Maracand, Ferghana, 6000 ft.]

129. *Notiophilus orientalis*, Chaud., Bull. Mosc. 2 : 428 (1850) FBI, 1 : 136 (1929).
*Kashmir; *Dharmsala [Simla Hills; Matiana; Muree; Kurram Valley; Parachinar; Central and West Almora; Upper Gumti Valley; East Ramganga Valley; Chakrata; Konaiu; Piliphil district.]

130. *Omophron axillaris* Chaud., Rev. et. Mag. Zool. p. 60 (1868) Mission Babault, p. 4 (1924)
*Bajaura (Kangra)

131. *Orthotrichus indicus* Bates, Compt. rend. Soc. Ent. Belg., (1891), 334; Mission Babault, p. 57 (1924)
*Kangra : Bajaura.

132. *Pardileus indicus* (Bates), Compt. rend. Soc. Ent. Belg., (1891), 332 (*Harpalus*); Mission Babault, p. 35 (1924)
*Spiti : Pulga, Tsho-ti, Tchary-Djoni; *Kangra : Bajaura; *Kulu : Kandi.

133. *Pardileus sinicus* (Hope), Trans. Ent. Soc. (1845), 14; (*Harpalus*); Mission Babault, p. 35 (1924)
*Kashmir : Baltal.

134. *Pheropsophus catoirei* (Dej), Spec. Gen. 1 : 301 (1825) Mission Babault, p. 55 (1924)
*Kangra : Bajaura; *Kulu: Naggar, Mandi; *Spiti: Gharry; *Kashmir : Baltal.

135. *Pheropsophus stenoderus* Chaud., Bull. Mosc. 1 : 77 (1850) Mission Babault, p. 56 (1924).
*Spiti : Gharry; *Kangra : Bajaura.

136. *Platymetopus flavilabris* (F.); in Mission Babault, p. 31 (1924).
*Kangra : Bajaura.

137. *Pristonychus kashmirensis babaulti* Andr., Mission Babault, p. 100 (1924).
Spiti: Tsho-ti, Tchary-Djoni, Pulga; Lahoul: Sisu, Kyelang, Sumdeo, Gondla; *Kulu: Kandy, Koty, Rotang Valley; *Kashmir: Sonemarg.

138. *Scarites bengalensis* Dej., Spec. Gen. 2 : 468 (1826) FBI, 1 : 247 (1929)
*Kashmir : Gurais Valley. [Bengal: Donapur; Bihar: Pusa, Chapra; China; Persia.]

139. *Scarites indus* Oliv., Entomologie, 3 : 36 (1795); Mission Babault, p. 10 (1924)
*Kulu : Mandi; *Kangra : Bajaura.

140. *Scarites praedator* Chaud., Mon. Scaritides, 2 : 97, (1880); Mission Babault, p. 10 (1924); FBI, 1 : 256 (1929).
*Spiti : Gharry; *Kashmir : Baltal, Sonemarg. [Assam; Sikkim; Bengal; Bihar; Orissa; Punjab; Bombay; Kodaikanal; Nilumbur; Burma; Rangoon.]

141. *Scarites sulcatus* Oliv., Entomologie 3: 36, 7 t. i, f. 11 (1795); Mission Babault, p. 10 (1924) ; FBI, 1 : 242 (1929) *Kulu; *Spiti: Manikarn; *Kangra : Bajaura. [Punjab: Murree, Baddia; Assam: Khasi Hills; Tinno; Nepal; Sikkim; U. P. Sitapur, Almora, Nainital, Garhwal; Burma : Bhamo, Towoy; China; Formosa; Korea; Java, Sumatra; Indo-China.]

142. *Sphodrus indus* Chaud., Bull. Mosc., 1 : 67 (1852); Mission Babault, p. 46 (1924).
Murree

143. *Stenolophus bajaurae* Andr., Mission Babault, p. 95 (1924)
*Kangra: Bajaura; *Spiti : Manikarn; *Kashmir.

144. *Stenolophus smaragulus* (F.), Suppl Ent. Syst. p. 60, (1798) Mission Babault, p. 40 (1924).
*Kangra : Bajaura.

145. *Tachys klugi* Nietner, AMNH, (3) 2 : 423 (1858); Mission Babault, p. 19 (1924); FBI, 2 (1) : 252 (1935)
*Kangra : Bajaura. [Common all over India; Ceylon, Burma; Malaya; Indo-China; Philippines and S. Japan.]

146. *Tachys latus* Peyron. Ann. Soc. Ent. France, p. 364, pl. 9, fig. 3 (1858); FBI, 2 (1) : 249 (1935).
*Kashmir: Sind Valley, Kangan. [W. Almora; Plains of

India (Bihar and U. P.) ; Burma; Sumatra; Cambodia, Tong-King; Annam; Asia Minor; Kurdistan.]

147. *Techys octostriatus* Neto., Att. Mus., Civ. Trieste, 12 : 100 (1934) ; FBI, 2 (1) 243 (1935).
*Kashmir : Sind Valley, Kangan, Sooroo Basin; *Kargil. [Bashahr: Sangla, 8000 ft.]

148. *Tachys stevensi* Andr., FBI, 2 (1) 263 (1935).
*Kangra. [Simla Hills, Tehri Garhwal, W. Almora; Bhim Tal; Dehra Dun; Bhiar; Orissa; Bengal.]

149. *Tetragonoderus arcuatus* Dej., Spec. Gen. 4 : 495 (2829) ; Mission Babault, p. 61 (1924)
*Kangra : Bajaura.

150. *Trechus beesoni* Jeann., in FBI, 2 (1) : 70, pl. I, fig. 7 (1935).
*Gulmarg, 8500 ft.

151. *Trechus cameroni* Jeann., AMNH, (9) 12 : 416, fig. 14 (1926); FBI, 2 (1) : 71 fig. 12 (1935) .
*Rotang Pass, 12,000 ft. [Simla Hills, 7000 ft, Narkandı 9200 ft. Tharoch 10,000 ft.] *Jalori Pass 10800 ft.

152. *Trechus cameronib istriatus* Jeann. AMNH, (10) 1 : 291 (1928) ; FBI, 2 (1) 72 (1935)
*Kangra: Kareri Lake.

153. *Trechus indicus championi* Jeann., AMNH, (9) 5 : 109 (1920; Mission Babault, p. 20 (1924); FBI, 2 (1) 65 (1935).
*Spiti : Pulga; Lahoul: Cimur; *Kashmir; Baltal and Sonemarg, Jalab Valley; *Dharmsala, Mandi, [Simla; Darjiling; Gopalda.]

154. *Trechus macrops* Jeann., in FBI, 2 (1) : 67 , fig. 10 (1935)
*Kashmir: Sonemarg. [Also Yunnan?]

155. *Trichocellus roborowskii* Tchitch., Hor. Soc. Ent. Ross., 32 : 455 (1899); Mission Babault, p. 41 (1924)
*Kashmir: Baltal; *Ladak : Leh; *Rupshu ; Lac Sale, Nima-Mud.

Family CICINDELLIDAE

156. *Cicindela albopunctata* Chaud., Bull. Soc. Moscou, p. 10 (1852); FBI, p. 378 (1912).
*Kangra Valley. [Simla; Mussurie; Moradabad; Chamusuri; Nepal; Sikkim; Kurseong; Darjiling; Bhutan.]

157. *Cicindela chloris* Hope, Gray's Zool. Miscell., p. 21 (1831) FBI, 376 (1912).
*Kashmir : Gilgit. [Sikkim : Rungpo; Nepal: Soondrijal; Benikhola; Sumdhik; Ghurwal; Hathikund; Jumnagwar; U. P. : Nainital, Jalabau, Kumaon.]

158. *Cicindela erudita* Wieden., Zool. Mag., 2 (1) : 68 (1823) FBI, p. 362 (1912).

*Kashmir; *Kulu. [U. P. Agra, Allahabad; Bengal: Maldah; Bihar: Chota Nagpur, Pusa.]

159. *Cicindela fastidiosa* Dejean, Spec. Col., 1:95 (1825) FBI, p. 352 (1912).
*Kashmir. [Rawalpindi; Sikkim; Assam; Kurseong; Bengal; Chota Nagpur; Central India; Mhow; Madras; Mysore; Ceylon; Burma.]

160. *Cicindela germianica kirilovi* Fisch, FBI, p. 354 (1912)
*Kashmir : Gilgit; [Western Siberia; Turkestan; Persia.]

161. *Cicindela intermedia*, Chaud., Bull. Soc. Moscou p. 6 (1852); FBI, p. 379 (1912).
*Kashmir: Jhelum Valley. [Punjab; Assam.]

162. *Cicindela octogramma* Chaud, Bull. Soc. Moscou p. 4 (1852); FBI, p. 404 (1912).
*Kangra Valley. [Bengal : Dinapur, Dharhar.]

163. *Cicindela sublacerata balucha* Bates, in FBI, p. 368 (1912)
*Kashmir : Skardo. [Baluchistan.]

164. *Neocollyris bonelli orytgia* Buq., FBI, p. 250 (1912).
*Kashmir. [Madras; Bengal; Nepal; Assam; Burma; South China; Tonkin; Siam; Cochin China; Malaya; Malaca; Sumatra; Java; Bali and other islands.

165. *Prothyma inornata* W. Hom., Deutsche Ent. Zietschr, p. 13 (1905); FBI, p. 305 (1912).
*Kulu. [Assam.]

166. *Prothyma limbata* (Wied), Zool. Mag. 2 (i) : 64 (1823) FBI, p. 304 (1912).
*Jhelum Valley. [Bengal : Calcutta; Punjab: Simla.]

Family PAUSSIDAE

167. *Platyrhopalus angustus major* Wasm., Notes Leyden Mus., 25 : 20 (1904); FBI, p. 460 (1912)
*Kashmir : Jhelum Valley. [Sind ; Madras; Bengal; U. P: Dehra Dun, Chandan Chowki; Assam: Dunsiri Valley.]

Family RHYSODIDAE

168. *Rhysodes boysi* Arrow, AMNH (7) 7: 87 (1901) : FBI, p. 505 (1912)
*Kashmir (?)

Family STAPHYLINIDAE

169. *Aleochara (Homoeochara) spassa* Heer., Faunn. Helv., 1: 317 (1838-42) FBI, 4 (2) : 640 (1939).
*Kashmir : Songam. [Chakrata: Konain, 8000 ft.]

170. *Aleochara (Mesochara) inornata* Cam., FBI, 4 (2): 643 (1939)
*Jalori Pass, 10,800 ft. [Chakrata: Deoban, 9330, ft; Dehra Dun; Kumaon; Nainital; West Bhalkot.]

171. *Aleochara* (*Polychara*) *beesoni* Cam., FBI, 4 (2) : 646 (1939)
*Kashmir: Gulmarg. [Chakrata: Bodyar, Dodora Khud; Binal Gad; Simla Hills: Fagu, 7000-8000 ft; W. Almora: Dhauli-Ganga.]

172. *Amischa kashmirica* Cam., FBI, 4 (1) : 275 (1939)
*Kashmir : Gulmarg.

173. *Anomognathus himalayicus* Cam., FBI, 4 (1) : 204 (1939)
*Kashmir: Gulmarg. [Simla Hills, Gahan, Kotgarh, Fagu, Narkanda, 9230 ft; Chakrata Distt: Kansar, 7000 ft; Mussurie : Mossyfall, W. Almora, Kumaon.]

174. *Atheta nigrolucens* Cam., FBI, 4 (1) : 343 (1939)
*Kashmir : Gulmarg, 8000-10,000 ft.

175. *Atheta nigrolucida* Cam., FBI, 4 (1) : 357 (1939)
*Mandi, Dhelu, 4500 ft. [Dehra Dun; Chakrata; Ghum; Assam: Mishmi Hills; Lohit River.]

176. *Atheta subsericans* Cam., FBI, 4 (1): 355 (1939)
*Kashmir : Gulmarg. [Simla Hills : Kotgarh; Chakrata; Chutti Khud; Mangoan.]

177. *Atheta triangulum* (Kr.), Naturg. Ins. Deutschl. 2: 273 (1856-58); FBI, 4 (1) : 356 (1939)
*Kashmir: Gulmarg, 8000-10,000 ft. [Simla Hills : Gahan, 7000 ft; Europe; Asia Minor.]

178. *Atheta* (*Acrotona*) *fungi* (*Gr.*), *kashmirensis*, Mon. Col. Micr., p. 157 (1806); FBI, 4 (1) : 404 (1939).
*Kashmir: Askoli (Braldo-Tal), 3100 m., Shimtsa (Punmah-Tal) 3200 m.

179. *Atheta* (*Acrotona*) *inquinata* Cam., FBI, 4 (1) : 407 (1939)
*Kashmir : Gulmarg, 8000-10,000 ft.

180. *Atheta* (*Acrotona*) *parva* (Sahlb.), Ins. Fenn., 1: 380 (1834) (*Alceochara*); FBI, 4 (1) : 398 (1939).
*Kashmir: Gulmarg. [Simla Hills: Narkanda; Chakrata: Konain; Almora: Dhauli Ganga, 6700-9200 ft.]

181. *Atheta* (*Aloconota*) *morosa* Cam., FBI, 4 (1): 290 (1939)
*Kashmir: Gulmarg, 8000-10,000 ft.

182. *Atheta* (*Datomicra*) *sordiduloides* Cam., FBI, 4 (1) : 386 (1939)
*Kashmir : Gulmarg, 8000-10,000 ft.

183. *Atheta* (*Datomicra*) *subarenicola* Cam., FBI, 4 (1) : 387 (1939)
*Kashmir: Gulmarg, 8000-10,000 ft.

184. *Atheta* (*Dimetrota*) *adjacens* Cam., FBI, 4 (1) : 380 (1939)
*Kashmir: Gulmarg, 8000-10,000 ft. [Simla Hills: Kotgarh, Narkanda, 7000-7250 ft.]

185. *Atheta* (*Dimetrota*) *associata* Cam., FBI, 4 (1) : 374 (1939)
*Kashmir: Gulmarg, 8000-10,000 ft.

186. *Atheta* (*Dimetrota*) *nigrans* Cam., FBI, 4 (1) 372 (1939)
*Kashmir: Gulmarg, 8000-10,000 ft.

187. *Atheta* (*Dimetrota*) *piceata* (Schub.) DEZ, p. 378 (1906); FBI, 4 (1) 372 (1939).
*Kashmir: Songam. [Chakrata: Deoban, 9330 ft.]

188. *Atheta* (*Dimetrota*) *suballocera* Cam., FBI, 4 (1) : 374 (1939)
*Kashmir: Gulmarg, 8000-10,000 ft.

189. *Atheta* (*Dimetrota*) *unicolor* Cam., FBI, 4 (1) : 374 (1939)
*Kashmir : Gulmarg.

190. *Atheta* (*Dralica*) *scrobicollis* (Kr.) Arch. Naturg., 15 : 31 (1859) (*Homotola*) ; FBI, 4 (1) : 306 (1939)
*Kashmir: Gulmarg. [Dehra Dun; Simla Hills: Matiana, 7900 ft; Europe.]

191. *Atheta* (*Hydrosmecta*) *kashmirica* Cam., FBI, 4 (1) : 283 (1939)
*Kashmir: Gulmarg.

192. *Atheta* (*Liogluta*) *subumbonata* Cam., FBI, 4 (1) : 367 (1939)
*Kashmir : Gulmarg, 8000-10,000 ft. [Chakrata: Deoban, 92000 ft.]

193. *Atheta* (*Metaxya*) *chatterjeei* Cam., FBI, 4 (1) : 300 (1939)
*Kangra. [Assam: Naga Hills; U. P. Chakrata, Chulli Khud, 8000 ft; Kumaon, Haldwani.]

194. *Atheta* (*Metaxya*) *incerta* Cam., FBI, 4 (1) : 301 (1939)
*Dharmsala.

195. *Atheta* (*Metaxya*) *soror* Cam., FBI, 4 (1) : 301 (1939)
*Kashmir: Gulmarg, 8000-9000 ft; *Pir Panjal, 7200 ft.

196. *Atheta* (*Microdota*) *amiculoides* Cam., FBI, 4 (1): 329 (1939)
*Kashmir: Gulmarg, 8000-10,000 ft.

197. *Atheta* (*Microdota*) *gracillima* Cam., FBI, 4 (1) : 334 (1939)
*Kashmir: Gulmarg, 8000-10,000 ft.

198. *Atheta* (*Microdota*) *subluctuosa* Cam., FBI, 4 (1) : 323 (1939)
*Kashmir : Gulmarg, 8000-10,000 ft.

199. *Atheta* (*Oreostilia*) *nimbicola* Cam., FBI, 4 (1) : 310 (1939)
*Kashmir : Aphar Wat, 13,000 ft., Gulmarg, 9000 ft.

200. *Atheta* (*Ousipalia*) *lentula* Cam., FBI, 4 (1) : 308 (1939)
*Kashmir : Gulmarg, 8000-9000 ft.

201. *Atheta* (*Ousipalia*) *tarda* Cam., FBI, 4 (1) : 309 (1939)
*Kashmir : Gulmarg, 8000-9000 ft.

202. *Atheta* (*Paraloconota*) *jaloriensis Cam.*, FBI, 4 (1) : 297 (1939)
*Jalori Pass, 10,800 ft, Bhabhu Pass, 9000 ft.

203. *Atheta* (*Paraloconota*) *muscicola* Cam., FBI, 4 (1) : 293, pl. ii, fig. 1 (1939)
*Kashmir; Gulmarg, 8000 ft, Khelanmarg, 10,000 ft; Kulu, Naggar, 5000 ft.

204. *Atheta* (*Traumoecia*) *praevia* Cam., FBI, 4 (1) : 316 (1939)
*Kashmir: Gulmarg, 8000-9000 ft.

205. *Atheta* (*Traumoecia*) *subcorticina* Cam., FBI, 4 (1) : 316 (1939)
*Kashmir: Gulmarg, 8000-9000 ft.

206. *Bolitobius decipiens* Cam., FBI, 3: 343 (1932)
*Kashmir: Gulmarg, 9000 ft.

207. *Bolitobius distinctus* Schub., DEZ, p. 381 (1906); FBI, 3: 340 (1932)
*Kashmir: Songam. [Simla Hills: Matiana, Gahan, Fagu; Chakrata: Sanasar, 6000 ft; Almora : Kali Valley, 9000 ft.]

208. *Bolitobius kashmiricus* Cam., FBI, 3: 343 (1932)
*Kashmir: Gulmarg, 8500 ft.

209. *Conosoma kashmiricum* Bernh., FBI, 3 : 363 (1932)
*Kashmir: Pir Panjal.

210. *Cryptobium rosti* Schub., DEZ, p. 622 (1908) ; FBI, 2: 249 (1931)
*Kulu. [Chakrata, Mussurie, 5000-75000 ft; Almora; Dwarka].

211. *Geodromicus kashmirensis* Cam., FBI, 1: 455 (1930)
*Kashmir: Gulmarg, Ferozpur Nala, 6500 ft.

212. *Gnypeta cyanea* Cam., FBI, 4 (1) : 270 (1939)
*Kashmir : Gulmarg.

213. *Gyrophaena cognata* Cam. FBI, 4 (1) : 106 (1939)
*Kashmir : Gulmarg.

214. *Gyrophaena densicollis* Cam., FBI, 4 (1) : 120 (1939)
*Kashmir: Gulmarg. [Simla Hills: Matiana, Narkanda, 7900-9200 ft.]

215. *Gyrophaena distincta* Cam., FBI, 4 (1) : 133 (1939)
*Kashmir : Gulmarg.

216. *Gyrophaena fletcheri* Cam., FBI, 4 (1) : 88 (1939)
*Kashmir : Gulmarg.

217. *Gyrophaena forcipata* Cam., FBI, 4 (1) : 80 (1939)
*Kashmir : Gulmarg.

218. *Gyrophaena indigena* Cam., FBI, 4 (1) : 81 (1939)
*Kashmir: Gulmarg.

219. *Gyrophaena kashmirensis* Bernh., Kol. Rund.ch., 10 : 127 (1922); FBI, 4 (1) : 105 (1939) *Kashmir: Uri.

220. *Gyrophaena permutaria* Schub., DEZ, p. 380 (1906)
*FBI, 4 (1) : 79 (1939) .
*Kashmir: Dusu, Songam, Sintan, Gulmarg.

221. *Gyrophaena quadrifida* Cam., FBI, 4 (1) : 108 (1939)
*Kashmir: Gulmarg.

222. *Gyrophaena soror* Berhn., Kol. Rundsch, 10: 127 (1922); FBI, 4 (1) : 106 (1939)
*Kashmir : Uri.

223. *Gyrophaena* (*Orphnebioidea*) *rosti* Schub., DEZ, p. 611 (1908); FBI, 4 (1) : 62 (1939).
*Kulu. [Simla Hills: Fagu, Matiana, Theog, 7000-8000 ft.

224. *Gyrophaena* (*Orphnebioidea*) *tuberculiventris* Bernh., Col. Rundsch. 4 : 58 (1915) ; FBI, 4 (1) : 64 (1939)
*Kashmir: Pir Panjal. [Simla Hills: Matiana, 7000 ft.]

225. *Hygrochara indica* Cam., FBI, 4 (1) : 44 (1939)
*Kashmir : Gulmarg. [Simla Hills: Fagu; Chakrata: Konian.]

226. *Hygrochara magniceps* Cam., FBI, 4 (1) : 45 (1939)
*Kashmir : Gulmarg.

227. *Ischnoglossa kashmirica* Cam., FBI, 4 (2) : 620 (1939)
*Kashmir : Gulmarg, 8000 ft.

228. *Lithrobium kashmiricum* Cam., FBI, 2 : 202 (1931)
*Kashmir: Ramsu, Chenab Valley, 4500 ft.

229. *Masuria ferruginea* Cam., FBI, 4 (1) : 28 (1939)
*Parbati Valley, 6000-8000 ft. [Mussurie, Mossy Falls; Chakrata, Khedar Khud; Simla Hills, Gahan, 7000-8000 ft.]

230. *Masuria picipes* Cam., EMM, p. 52 (1928); FBI, 5 (1) : 27 (1939).
*Parbatti Valley, 6000-8000 ft., Phabbu Pass, Naggar, Jibhi, Seraj, 5000-9000 ft. [Chakrata, Sainj Khud, 6500 ft.]

231. *Masuria phimbea* Cam., FBI, 4 (1) : 26 (1939)
*Triun, 9300 ft. [Mussurie; Chakrata; Almora; Kumaon; Gori River.]

232. *Myllaena infuscata* Kr., Stett. Ent. Zeit., 14 : 373 (1853); FBI, 4 (1) : 20 (1939).
*Kashmir: Gulmarg, 8000 ft. [Europe and N. America.]

233. *Myllaena monticola* Cam., FBI, 4 (1) : 18 (1939)
*Kulu, Naggar. [Mussurie; Chakrata; Simla Hills, Upper Gundi Valley; Ghum Dist. : Mangpu; Assam: Shugun, 3000-8000 ft.]

234. *Neoleptusa brunnea* Cam., FBI, 4 (1) : 215 (1939)
*Kashmir : Gulmarg. [Simla Hills; Chakrata; Mussurie.]

235. *Ocalea himalayica* Cam., FBI, 4 (2) : 578 (1939)
*Kashmir: Gulmarg; *Punjab: Naggar. [Simla, Chakrata; N. W. F. P., Hazara; Upper Kangan Valley; Naddi, 8000 ft.]

236. *Ocyusa (Cousya) quadrisulcata* Bernh., Att. Mus. Civ. Stov. Nat. Trieste, 12: 87 (1934); FBI, 4 (2) : 586 (1939)
*Kashmir: Balturo, Mundu, 4300 m., Urdukas, 4000 m Lopsang Bransa, 4500 m., Liligo, 3800 m, Biaho-tal; Paju

237. *Omalium altivagans* Bernh., Kol. Rundsch, p. 49 (1915); FBI, 1: 140 (1930).
*Kashmir: Sintan.

238. *Oxypoda himalayica* Cam., FBI, 4 (2) : 596 (1939)
*Jibhi, Seraj, 6000 ft., Jhatingri, Mandi, 6000 ft. [Simla Hills: Kotkai, 5500 ft; Chakrata; Mussurie, W. Almora, 6000-8000 ft; Upper Gumti Valley.]

239. *Oxypoda (Mycetodrepa) marginalis* Cam., FBI, 4 (2) : 613 (1939)
*Naggar, 5000 ft., Bhabbu Pass, 9000 ft. [Chakrata, 7000-9000 ft; Mussurie, 6000 ft.]

240. *Oxypoda (Podoxya) montivaga* Cam., FBI, 4 (2) : 600 (1939)
*Jalori Pass, 10,800 ft. [Chakrata: Binal; Gad; Konain; Beoban; 7000-9330 ft; W. Almora, Kumaon.]

241. *Oxypoda (Podoxya) nigrita* Cam., FBI, 4 (2) : 602 (1939)
*Jalori Pass, 10,800 ft, Jibhi, Seraj, 6000 ft,

*Kashmir: Gulmarg, 8000-10000 ft. [Simla Hills, 7000-7900 ft. Chakrata: Khedar Khud; Deoban, 7500-7900 ft; Kumaon, Upper Gumti Valley.]

242. *Oxypoda* (*Podoxya*) *subsericea* Cam., FBI, 4 (2) : 603 (1939)
*Kashmir : Gulmarg. [Dehra Dun; Bombay; Kanara; Mussurie, Chakrata; Simla Hills.]

243. *Oxypoda* (*Podoxya*) *uniformis* Cam., FBI, 4 (2) : 601 (1939)
*Kashmir: Gulmarg, 8000-9000 ft.

244. *Oxytelus* (*Anotylus*) *tibialis* Schub., DEZ, p. 626 (1908) ; FBI, 242 (1930).
*Kulu.

245. *Oxytelus* (*Tanycraerus*) *robustus* Schub. DEZ, p. 383 (1906); FBI, 1: 228 (1930).
*Kashmir : Sintan.

246. *Paederus kuluensis* Bernh., WZB, p. 99 (1914); FBI, 2 : 55 (1931)
*Kulu.

247. *Philonthus aliquetenus* Schub., DEZ, p. 618 (1908); FBI, 3 : 107 (1932)
*Kulu, 2000 m. [Simla; Chakrata, 6000-7000 ft.]

248. *Philonthus basipilosus* Schub., DEZ., 621 (1908); FBI, 3: 140 (1932).
*Kulu. [Bashahar State, 6000-8000 ft.]

249. *Philonthus batotensis* Cam., FBI, 3 : 99 (1932).
*Kashmir : Udhampur division, Batote, 5500 ft.,

250. *Philonthus diversus* Schub., DEZ., p. 382 (1906); FBI, 3: 95 (1932).
*Kashmir : Sintan, Shishram Nag, Liden Valley, 12, 000 ft.

251. *Philonthus frontalis* Schub., DEZ, p. 616 (1908); FBI, 3 : 107 (1932).
*Kulu, 2000 m. [Simla; Chakrata Division, 6000-9000 ft.]

252. *Philonthus himalayicus* Bernh., Kol. Rundsch, p. 52 (1915); FBI, 3 : 144 (1932).
*Kulu: 10,000 ft.

253. *Philonthus kashmirenus* Bernh., Kol. Rundsch, p. 52 (1915); FBI, 3 : 126 (1932)
*Kashmir: Kisthwar Panjal.

254. *Philonthus kashmiricus* Cam., FBI, 3 : 94 (1932).
*Kashmir : Sind Valley, Haran Plantation.

255. *Philonthus kuluensis* Schub., DEZ, p. 617 (1908); FBI, 3 : 108 (1932).
*Kulu, 1500 m.

256. *Philonthus lapidicola* Cam., FBI, 3 : 145 (1932)
*Kashmir: Gulmarg, Ferozepur Nala, 6500 ft.

257. *Philonthus lidarensis* Cam., FBI, 3 : 94 (1932)
*Kashmir : Lidar Valley, Liderwat, 9000 ft.

258. *Philonthus peregrinus* Fauv., Ann. Soc. Ent. France, (4) 6 : 315 (1866); FBI, 3 : 133 (1932).
*Chamba. [Dehra Dun; Chakrata Division; Africa ; Madagascar; Comoro Island; Mauritius; Reunion of Seychellus.]

259. *Philonthus protenus* Schub., DEZ, p. 382 (1906); FBI, 3 : 95 (1932).
*Kashmir : Songam, Sind Valley. [Simla Hills; Mussurie; Chakrata, 5500-8000 ft.]

260. *Philonthus proximatus* Schub., DEZ, p. 616 (1908); FBI, 3 : 82 (1932).
*Kulu. [Chakrata; Mussurie, 6000-8000 ft.]

261. *Philonthus signifrons* Schub., DEZ, p. 618 (1908); FBI, 3 : 106 (1932).
*Kulu, 2000 m.

262. *Phlocopora himalayica* Cam., FBI, 4 (2) : 564 (1939)
*Kashmir: Gulmarg, 8000 ft. [Simla Hills : Gahan, 7000 ft.]

263. *Phymatura picta* Cam., FBI, 4 (1) : 219 (1939)
*Kashmir : Gulmarg. [Simla Hills: Gahan, Narkanda, 7000-9000 ft.]

264. *Priochirus (Palastus) kuluensis* Bernh., WZB, p. 78 (1914) ; FBI, 1: 113 (1930).
*Kulu. [W. Almora, Kumaon.]

265. *Pseudocyusa kashmirica* Cam., FBI, 4 (2) : 592 (1939)
*Kashmir: Gulmarg, Khilanmarg, 8000-10,000 ft.

266. *Quedius (Raphirus) kashmiricus* Cam., FBI, 3 : 296 (1932)
*Kashmir : Gulmarg, 8000 ft.

267. *Rheochara simlaensis* Cam., FBI, 4 (2) : 652 (1939)
*Kashmir: Gulmarg. [Simla Hills : Fagu, 8000 ft.]

268. *Securipalpus rudepunctatus* Schub., DEZ, p. 613 (1908); FBI, 3 : 275 (1932).
*Kulu, 3500 m.

269. *Silusa nigra* Cam., FBI, 4 (1) : 183 (1939)
*Kashmir : Gulmarg.

270. *Staphylinus (Platydracus) dudgeoni* Cam., FBI, 3 : 196 (1932)
*Kangra valley, 4500 ft.

271. *Staphylinus (Platydracus) submarmorellus* Schub., FBI, 3 : 194 (1932)
*Kulu. [Dehra Dun.]

272. *Staphylinus (Pseudocypus) almorensis* Cam., FBI, 3 : 204 (1939)
*Triun, 9300 ft. [W. Almora, Kali valley, 9000 ft.]

273. *Stenus (Mesostenus) aceris* Steph., Ill. Brit. Ent. 5 : 292 (1832), FBI, 1: 400 (1930).
Western Himalayas. [Europe.]

274. *Sulepta kashmirica* Cam., FBI, 4 (1) : 217 (1939)
*Kashmir : Gulmarg.

275. *Tachinus beesoni* Cam., FBI, 3 : 396 (1932)
*Kashmir : Khilanmarg, 11,000 ft.

276. *Tachinus scroteus* Schub., DEZ, p. 612 (1908); FBI, 3 : 394. (1939).
*Jalori.

277. *Tachyporus montanus* Bernh., Col. Rundsch, 4 : 58 (1915); FBI, 3 : 383 (1932).
*Jalori. [Dehra Dun.]

278. *Tachyusa (Caliusa) schuberti* Jacob., Käf. Russl. p. 540 (1909); FBI, 4 (1) : 268 (1939).
*Kashmir : Jhelum Valley.

279. *Thamiaraea championi* Cam., FBI, 4 (2) : 435 (1939)
*Kulu, Naggar, 6000 ft. [Simla Hills, Kotgarh, 7000 ft.]

280. *Thamiaraea montana* Cam., FBI, 4 (2) : 440 (1939)
*Kashmir : Gulmarg, 8000 ft. [Simla Hills : Theog, Phagu, Matiana, 7600-7900 ft, Jaunsar, Mandali.]

281. *Tinotus kashmiricus* Cam., FBI, 4 (2) : 559 (1939).
*Kashmir : Gulmarg. [Simla Hills : Matiana.]

282. *Zyras exasperatus* Schub., DEZ, p. 610 (1908); FBI, 4 (2) : 536 (1939)
*Kulu, 3000 m.

283. *Zyras kraatzi* Schub., DEZ., p. 609 (1908); FBI, 4 (2) : 536 (1939)
*Kulu. [Chakrata, Jaunsar.]

284. *Zyras* (*Pella*) *kuluensis* Cam., FBI, 4 (2) : 545 (1939)
*Kulu: Naggar, 5000 ft.

285. *Zyras* (*Rhynchodonia*) *bicolor* (Epp.), DEZ, p. 388 (1895) (*Myrmedonia*); FBI, 4 (2) : 504 (1939).
*Palampur, Kangra Valley, 4500 ft. [Calcutta.]

Family HISTERIDAE

286. *Hister assamensis* Marseul, Mon. p. 409, t. 10, fig. 11 (1857); Mission Babault, p. 5 (1921).
*Kangra : Bajaura.

287. *Hister* (*Atholus*) *pirithous* Marseul, Ann. Soc. Ent. France, p. 224 (1873) ; Mission Babault, p. 10 (1921)
*Spiti : Pulga, Manikarn.

288. *Hister cadaverinus* Hoffm., Entom., 1 : 34 (1803) ; Mission Babault, p. 6 (1921)
*Spiti : Pulga.

289. *Hister indiicola* Desbordes, Mission Babault, p. 7 (1921)
*Spiti : Pulga; *Kulu : Kandi; *Lahoul : Kyelang, Sumdeo, Sisu.

290. *Hister jekali* Marseul, Mon., p. 417 (1857) ; Mission Babault, p. 6 (1921).
*Bajaura (Kangra).

291. *Hister* (*Pachylister*) *bengalensis* Wied. Germ. Mag., 4 : 122 (1821); Mission Babault, p. 4 (1921).
*Kangra. [Punjab : Kutola.]

292. *Hister* (*Pachylister*) *bitarius* Erich., Jahrb. Ins. 1 : 133 (1834) ; Mission Babault, p. 5 (1921).
*Kulu : Kandi ; Kangra : Bajaura. [Punjab: Bilaspur, Kutola.]

293. *Hister* (*Pachylister*) *reflexilabris* Marseul, Mon. p. 187, t. 6, fig. 9, (1854); Mission Babault, p. 5 (1921)
*Kangra : Bajaura, Kulu : Mandi. [Punjab : Kutola.]

294. *Hister pullatus* Erich., Jahrb. Ins., 1 : 138 (1834) ; Mission Babault, p. 6 (1921).

*Spiti : Manikarn, Ghary. [Punjab: Badia, Blaspur, Dahora.]

295. *Hister* (*Santalus*) *orientalis* Payk., Mon. Hist., p. 17 (1811) Mission Babault, p. 3 (1921).
*Kangra: Bajaura, Mandi. [Magjoan; Garhit; Chilpi; Jangli; Moti Nala; Kapa; Dhaniohai; Punjab : Nalagarh, Blaspur, Mandla, Kalka.]

296. *Hister scissifrons* Marseul, Mon. p. 240 (1854) ; Mission Babault, p. 6 (1921)
*Kangra : Bajaura. [Punjab : Badia, Nalagarh, Blaspur.]

297. *Saprinus speciosus* Erich., Jahrb. Ins. 1: 179 (1834) ; Mission Babault, p. 12 (1921).
*Kangra : Bajaura.

298. *Saprinus optabilis* Marseul, Mon., p. 438 (1855); Mission Babault, p. 12 (1921).
*Kangra : Bajaura. [Punjab : Dahora.]

299. *Saprinus ovalis* Marseul, Mon. p. 382, t. 1, fig. 24 (1855); Mission Babault, p. 12 (1921).
*Kangra: Bajaura.

300. *Saprinus quadriguttatus lateralis* Illiger, Illiger's Mag., 6 : 36 (1807); Mission Babault, p. 12 (1921)
*Kangra: Bajaura.

301. *Saprinus semistriatus* Scriba, *J. Liebh. Ent.*, p. 72 (1790); Mission Babault, p. 13 (1921)
*Kangra : Bajaura.

302. *Saprinus* (*Hypocaccus*) *apricarius* Erich., Jahrb. Ins., 1 : 194 (1834); Mission Babault, p. 13 (1921).

Family CURCULIONIDAE

303. *Achlaenomus babaulti* Hustache, Mission Babault, p. 8 (1928).
*Kashmir; *Ladak : Leh, frontior of Tibet, *Rupshu *Lac Sale, Tsho-Morari.

304. *Achlaenomus squamulosus* Hustache, Mission Babault, p. 7 (1928).
*Lahoul: Patsseo, Zingzingbar, Sisu, Valley Rotang. *Kashmir; *Koty.

305. *Acythopeus babaulti* Hustache, Mission Babault, p. 17 (1928).
*Kangra : Bajaura.

306. *Blosyrodes pubescens* Marsh., FBI, p. 39, 41 (1916) ; Mission Babault, p. 1 (1928).
*Valley Rotang, Sisu (Lahoul); *Kashmir : Jarjii, 11,200 ft. towards Gilgit. [Baluchistan.]

307. *Blosyrodes quadrinodosus* Jekel, Col. Jekel, p. 159 (1875); FBI, p. 39 (1916).
*Dalhousie. [Murree.]

308. *Blosyrodes variegatus* (Redt.), Hügel's Kaschm, 4:539 (1848); FBI, p. 40 (1916); Mission Babault, p. 2 (1928)

*Kashmir; *Kangra : Bajaura; Tchary-Djoni; Spiti : Pulga; *Gond (Kashmir). [Mussurie.]

309. *Calomycterus distans* (Faust), Stett. Ent. Zeit. 47 : 146 (1886); Mission Babault, p. 11 (1928).
*Spiti, Tchary Djoni, Pulga.

310. *Catopionus basilicus* Schönh, Gen. Curc., 6 : 247 (1842) ; Mission Babault, p. 2 (1928).
*Kashmir; Koty; Gilgit; *Spiti, Tchary-Djoni.

311. *Cleonus* (*Pseudocleonus*) *dauricus* Gebl., Ledeb., Reise, p. 157 (1830); Mission Babault, p. 16 (1928).
*Kashmir : Baltal, Sonemarg.

312. *Dereodus pollinosus* Redt., Hügel's Kaschm., 4 :2 (1848); FBI, p. 121 (1916); Mission Babault, p. 3 (1928)
*Kashmir; *Kangra: Bajaura. [Baluchistan; Kalka Simla; Mussurie; Almora; Dehra Dun; Thadiar, 7000 ft; Nepal; Dharampur, 5000 ft.]

313. *Dereodus sparsus* Bohem., Schönh, Gen. Curc., 6 : (1) : 208 (1840); FBI, p. 121 (1916); Mission Babault, p. 3 (1928)
*Kangra : Bajaura; *Kulu : Mandi. [W. Bengal; Madras; Trivandrum; Ceylon; Bombay; Ganjan Dist. Surada.]

314. *Emperorrhinus defoliator* Marsh. Bull. Ent. Res., 6 (4) : 365 (1916); FBI, p. 286 (1916).
*Chawai, Kulu, Kangra Distt. [Sikkim : Kurseong, 6000 ft. Darjiling; Assam: Khasi Hills.]

315. *Heteronyx ferus* Faust., Hor. Soc. Ent. Ross., 20 : 173 (1886); Mission Babault, p. 15 (1928).
*Spiti : Tchary Djoni, Sho-Ti, Pulga.

316. *Heteronyx ferus loevior* Hust., Mission Babault, p. 16, (1928).
*Lahoul : Sisu, Valley Rotang.

317. *Hylobius angustus* Faust., Stett. Ent. Zeit., p. 278 (1891); Mission Babault, p. 16 (1928).
*Kulu, Naggar.

318. *Hyperstylus chloris* Marsh., FBI, p. 353 (1916); Mission Babault, p. 10 (1928).
*Kangra : Bajaura.

319. *Lagenolobus adspersus* Faust., Deut. Ent. Zeit., p. 382 (1879); Mission Babault, p. 12 (1928).
*Kangra: Bajaura.

320. *Lagenolobus lineolatus* Hust., Mission Babault, p. 12 (1928).
*Tibet frontier, Rupshu, Lac Salé, Tsho-Morari, Nima-mud, Ladak : Leh; Kashmir.

321. *Lagenolobus pubescens* Hust., Mission Babault, p. 11 (1928).
*Kashmir; *Koty, Valley Rotang.

322. *Lagenolobus tutus* Faust., Deut. Ent. Zeit., p. 382 (1879); Mission Babault, p. 11 (1928).
*Kashmir; Koty.

323. *Leptomias angustatus* (Redt.), Hugels Kaschm., 4 (2) : 542 (1848); FBI, p. 177 (1916).
*Kashmir. [Mussurie.]

324. *Leptomias audax* Faust., Stettin. Ent. Zeit, p. 134 (1886); FBI, p. 188 (1916).
*Jhelum Valley.

325. *Leptomias bipustulatus* Faust., Deut. Ent. Zeit., p. 342 (1897); FBI, p. 184 (1916); Mission Babault, p. 4 (1928)
*Kangra : Bajaura; Chamba, Dalhousie. [Dehra Dun; Almorah, 5500 ft; Kumaon.]

326. *Leptomias costatus* (Faust), Deuts. ent. Zeit. p. 345 (1897) (*Perisomias*); FBI, p. 176 (1916).
*Dalhousie.

327. *Leptomias cylindricus* Marsh., FBI, p. 186 (1916).
*Dalhousie. [Baluchistan : Kaha Pass.]

328. *Leptomias invidus* Faust., Stettin. Ent. Zeit, p. 136 (1886); FBI, p. 185 (1916).
*Kashmir : Sind Valley.

329. *Leptomias lituratus* (Redt.), Hügel's Kaschm., 4 (2) : 543 (1848) (*Cneorhinus*); FBI, p. 179 (1916)
*Kashmir. [Mussurie; Mandali, 9000 ft; Jaunsar; Dehra Dun.]

330. *Leptomias marshalli* Hust., Mission Babault, p. 4 (1928);
*Lahoul: Sumdeo, Kyelang, Gondla.

331. *Leptomias praetermissus* Marsh., FBI, p. 186 (1916).
*Chamba.

332. *Leptomias sabulosus* Faust., Deut. Ent. Zeit., p. 341 (1897); FBI, p. 186 (1916).
*Chamba (Punjab).

333. *Leptomias scrobicollis* Marsh., FBI, p. 181 (1916); Mission Babault, p. 5 (1928).
*Spiti: Tchary-Djoni, Pulga; *Kashmir.

334. *Leptomias setulosus* Marsh., FBI, p. 177 (1916).
*Kashmir: Sonemarg, 8600 ft.

335. *Leptomias spinifer* Marsh. FBI, p. 176 (1916).
*Kashmir : Sonemarg, 8600 ft.

336. *Leptomias stoliczkae* Faust., Stettin. Ent. Zeit. p. 137 (1886); FBI, p. 182 (1916).
*Kashmir. [Murree.]

337. *Leptomias stultus* Faust., Deut. Ent. Zeit. p. 340 (1897); FBI, p. 184 (1916).
*Chamba; *Dalhousie.

338. *Myllocerus discolor* Bohem. Gen. Curc., 2, p. 428 (1834); FBI, p. 348 (1916) Mission Babault, p. 10 (1928).

*Kangra : Bajaura; Rampur, Sutlej Valley. [Punjab: Patiala; U. P. : Almora, Takula, Kumaon, Dehra Dun, Allahabad; Calcutta: Champaran; Jamalpur; Dacca; Kanti; Orrissa; Pusa [Bihar)].

339. *Myllocerus kashmirensis* Marsh., FBI, p. 308 (1916); Mission Babault, p. 10 (1928).
*Kashmir : Jhelum Valley: *Spiti : Pulga.

340. *Myllocerus pilifer* Faust, Deut. Ent. Zeit., p. 367 (1897); FBI, p. 307 (1916).
*Punjab : Chamba.

341. *Myllocerus rusticus* Faust., Deut. Ent. Zeit., p. 368 (1897); FBI, p. 306 (1916).
*Kashmir, Chamba.

342. *Myllocerus sericeus* Faust., Deut. Ent. Zeit., p. 362. (1897); FBI, p. 309 (1916).
*Dalhousie, Chamba.

343. *Myllocerus transmarinus* (Herbst), Käfer, 4 : 213, pl. 75, f. 1 (1795); FBI, p. 337 fig. 102 (1916); Mission Babault, p. 10 (1928).
*Kangra : Bajaura; *Kulu, *Bashahr; *Sutlej; [Kalka; N. Kangra; Dehra Dun; Madras; Calcutta; Pusa; Nagpur; Poona.]

344. *Myllocerus* 11-*pustulatus* var. *maculosus* Desbr., Ind. Mus. Notes, 4 : 111 (1899); FBI, p. 351 (1916)
*Sutlej Valley, *Kulu, *Bashahar State. [Madras; Banglore; Lyallpore; Hafizabad; Chiniot; Lahore; Kaithar; Puneah; Pusa; Chapra; Dacca; Muzaffarpur; Cuttack; Orrissa.]

345. *Otiorrhynchus amaenus* Faust, Stett. Ent. Zeit., p. 139 (1886); FBI, p. 256 (1916).
*Kashmir.

346. *Otiorrhynchus russicus* Stieril. Mitt. Schwiez. Ent. Ges. 6 : 544 (1883); FBI, p. 257 (1916).
*Kashmir : Sirikol. [Russia; Tchaar-Tasch, 11,000 ft.]

347. *Otiorrhynchus striolaticeps* Marsh., FBI, p. 258 (1916).
*Kashmir : Sonemarg.

348. *Pachynotus globulicollis* Redt., Hügel's Kaschm, 4 (2) : 541, pl. 26, fig. 5 (1898); FBI, p. 201, (1916)
*Kashmir. [Mussurie, 7000 ft; Dehra Dun; Mandali, 9000 ft; Jaunsar; Bargarkote; 8000 ft; Kumaon; Painsur; above Lobha, 8000 ft; Garhwal.]

349. *Phytonomus auceps* Bohem., Gen. Curc., 6 (2) : 348; Mission Babault, p. 14 (1928).
*Kashmir : Baltal.

350. *Phytonomus variabilis* Herbst, Käfer, 6, p. 263, pl. 80, fig. 1; Mission Babault, p. 14, (1928).
*Kangra: Bajaura.

135. *Ptochus* (?) *crinitus* (Redt.), Hügel's Kaschmir, 4 (2) : 547 (1848); FBI, p. 274 (1916).
*Kashmir.

352. *Ptochus noxius* Faust., Deut. Ent. Zeit, p. 353 (1897); FBI, p. 271 (1916).
*Dalhousie, Kangra. [Simla.]

353. *Rhyncolus himalayensis* Stebb., Indian For. Ins., p. 451; Mission Babault, p. 20 (1928).
*Spiti : Tchary-Djoni, Manikarn, Bajaura.

354. *Scepticus callosus* Hust., Mission Babault, p. 2 (1928)
*Bajaura (Kangra).

355. *Scepticus caesius* Marsh., FBI, p. 65 (1916).
*Kashmir : Gilgit, 5000 ft.

356. *Scepticus kashmirensis* Marsh., FBI, p. 65, fig. 21 (1916); Mission Babault, p. 3 (1928).
*Kashmir : Gond, Sonemarg, 8600 ft.

357. *Scepticus noxius* (Faust), Stett. Ent. Zeit. p. 130 (1886) (*Thylacites*); FBI, 64 (1916).
*Kahsmir : Sirikol. [Turkestan.]

358. *Scepticus nubifer* Faust, Stett. Ent. Zeit. p. 131 (1886); FBI, p. 65 (1916); Mission Babault, p. 3 (1928).
*Ladak : Leh, Kargil, Dras; *Lahoul: Zingingbar, Patséo, Sisu, Kyelang, Sumdeo; *Kashmir : Baltal, Sonemarg, Gond, Tibet Frontier,Rupshu, Tsho-Morari.

359. *Sitones callosus* Gyll., Gen. Curc., 2 : 108 ; Mission Babault, p. 13 (1928).
*Lahoul, Gondla.

360. *Sitones crinitus* Oliv., Ent., 5, 83: 382, pl. 35, fig. 550; Mission Babault, p. 13 (1928).
*Kangra : Bajaura.

361. *Sitones vergicolor* Fust, Stett. Ent. Zeit., 48, p. 180; Mission Babault, p. 13 (1928);
*Lahoul : Sumdeo, Kyelang.

362. *Xylinophorus affinis* Hust., Mission Babault, p. 5 (1928).
*Spiti : Pulga.

363. *Xylinophorus minutus* Hust., Mission Babault, p. 6 (1928).
*Bajaura (Kangra).

364. *Xylinophorus peregrinus* Faust, Deut. Ent. Zeit., p. 346 (1897); FBI, p. 192 (1916).
*Dalhousie

365. *Xylinophorus prodromus* Faust, Deut. Ent. Zeit., p. 177 (1885); FBI, p. 192 (1916).
*Kashmir : Sirikol. [Turkestan.]

Order HYMENOPTERA‡

Superfamily *Ichneumonoidea*

Family EVANIIDAE

1. *Evania montana* Kieffer, Ann. Soc. Ent. France, 80 : 165 (1911); Das Tierr., Lief. 30 : 99 (1912); Cat. Indian Ins. 24 : 6 (1939).
   *Kangra.
2. *Evania origena* Kieffer, Ann. Soc. Ent. France, 80 : 164 (1911); Cat. Indian Ins., 24 : 6 (1939).
   *Kangra.
3. *Gastruption kashmirense* Cam., J. B. N. H. S., 17 : 292 (1906); Cat. Indian Ins., 24 : 6 (1939).
   *Kashmir.
4. *Parevania kasauliensis* Muzaffer, Indian J. Ent., 5 : 6 (1943).
   *N. W. Himalayas. [Kasauli.]

Family ICHNEUMONIDAE

5. *Anomalon foliator* (Fabr.), Ent. Syst., Suppl. 1798, p. 239 (*Ophion*); FBI, 3 : 397 (1913) (*Nototrachys*).
   *Kangra Valley, 4500 ft. [Throughout India; Europe; America.]
6. *Campoplex longipes* Smith, 2nd. Yark. Miss., p. 21 (1878); FBI, 3 : 464 (1913).
   *Kashmir : Sind Valley.
7. *Campoplex zonatus* Morl., FBI, 3 : 455 (1913)
   *Kangra Valley. [Simla].
8. *Cephalobolus parvipes* Morl., FBI, 3 : 444 (1913)
   *Kashmir, 5000-6000 ft.
9. *Diplazon clotho* (Morl.), FBI, 3 : 281 (1913) (*Bassus*)
   *Kashmir, 6000-7000 ft. [Pusa; Nagpur; Surat; Poona.]
10. *Diplazon laetatorius* (Fabr.), Spec. Ins. 1 : 424 (1781) (*Ichneumon*); FBI, 3 : 276 (1913) (*Bassus*)
    *Kashmir. [Quetta, Punjab : Gojra, Ferozepur; Rajasthan Mt. Abu. Cosmopolitan.]
11. *Enicospilus merdarius* (Grav.), Ichn. Eur. 3 : 698 (1829) (*Ophion*); FBI, 3 : 389 (1913) (*Henicospilus*)
    *Kangra Valley. [Dehra Dun and throughout Oriental region.]
12. *Enicospilus reticulatus* Cam., Faun. Mald. et. Laccad. Arcg. 1 : 51 (1902) (*nec.* Cameron 1899); FBI, 3 : 388 (1913) (*Henicospilus*)
    *Kangra Valley, 4500 ft. [Maldive Islands; Burma; Malaya; Sarawak; Celebes; Ceram.]
13. *Enicospilus sinuatus* (Morl.), Revis. Ichn. B. M., p. 24 (1912) (*Allocamptus*); FBI, 3 : 374 (1913) (*Allocamptus*)

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†The generic synonomy is revised after Muesebeck, 1951. U. S. Dep. Agric. mon. 2., Washington.

*Punjab : Kangra Valley, 4500 ft. [Bengal; Assam: Burma; Ceylon.]

14. *Eponites ruficornis* Cam., Zeit. Hym.-Dip., p. 77 (1905); FBI, 3 : 259 (1913).
    *Kashmir, 5000-6000 ft. [Sikkim; Darjiling; Bengal; Pusa.]
15. *Exetastes fornicator* (Fabr.), Sp. Ins. 1 : 432 (*Ichneumon*); FBI, 3 : 250 (1913).
    *Kashmir, 8000-9000 ft. [Europe.]
16. *Exochus parca* Morl., FBI, 3 : 296 (1913).
    *Kangra Valley, 4500 ft. [Shillong, 6000 ft; Ceylon.]
17. *Hyposoter ebenina* (Grav.), Ichn. Eur. 3 : 480 (1829) (*Campoplex*); FBI, 3 : 494 (1913) (*Anilasta*)
    *Kashmir, 8000-9000 ft. [Shillong, 6000 ft; Europe.]
18. *Hyposoter simlaensis* (Cam.), Zeits. Hym.-Dip. 5 : 283 (1905) (*Limneria*); FBI, 3 : 495 (1913) (*Anilasta*)
    *Kashmir, 6000 ft. [Simla.]
19. *Itoplectis alternans* (Grav.), Ichn. Eur. 3 : 201 (*Pimpla*); FBI, 3 : 169 (1913).
    *Kashmir, 5000-6000 ft. [Simla.]
20. *Mesoleius wahlbergi* Holmg., Sv. Ak. Handl., p. 13 (1876); FBI, 3: 329 (1913).
    *Kashmir, 6000 ft. [Lapland.]
21. *Olesicampe quettaense* (Cam.), J. B. N. H. S., p. 280 (1906), (*Limnerium*); FBI, 3 : 483 (1913) (*Limnerium*).
    *Kangra Valley. [Quetta; Simla, 7000 ft., Kasauli, 6300 ft; Darjiling, 6000 ft.]
22. *Ophion albopictus* Smith, 2nd Yark. Miss., p. 22 (1878); FBI, 3 : 370 (1913).
    *Kashmir.
23. *Ophion dentatus* Smith, 2nd Yark. Miss., p. 22 (1878); FBI, 3 : 336 (1913).
    *Kashmir : Sind Valley. [Sikkim.]
24. *Ophion montanus* (Cam.), J. B. N. H. S., p. 291 (1906) (*Paniscus*); FBI, 3 : 356 (1913) (*Paniscus*).
    *Kashmir, 5000-6000 ft. [Madras; Bangalore.]
25. *Ophion ocellaris* (Thoms.) Opsc. Ent. 12: 1199 (*Paniscus*); FBI, 3 : 350 (1913) (*Paniscus*).
    *Kashmir, 5000-6000 ft; *Kangra Valley. [Simla; Kasauli; Dehra Dun; Mussurie; Ghoom; 7500 ft; Darjiling; Kurseong; Khasi Hills; Shillong; Manipur; Pusa; Chapra; Calcutta; Bombay; Ceylon; Tenasserim; Europe.]
26. *Ophion renovatus* (Morl.), FBI, 3 : 354 (1913) (*Paniscus*)
    *Murree.
27. *Pimpla instigator* (Fabr.) var. *intermedia* Morl., FBI, 3 : 156 (1913)
    *Kashmir. [*P. instigator* cosmopolitan throughout India and Europe.]

28. *Rhyssa persuaroria* (Linn.), Faun. Suec. p. 400 (*Ichneumon*); FBI, 3 : 92 (1913).
N. W. Himalayas. [Tehri-Garhwal; U. S. A. Canada; Yesso in N. Japan and from Spruce woods at Deota. Cosmopolitan spp.]

29. *Scambus nursei* (Cam.), J. B. N. H. S., 17 : 283 (1906) (*Pimpla*); FBI, 3 : 174 (1913) (*Epiurus*).
*Kashmir, 5000-6000 ft. [Baluchistan : Quetta.]

30 *Seolobates auriculatus* (Fabr.), Piez., p. 69 (1804) (*Ichneumon*); FBI, 3 : 339 (1913).
*Kashmir, 5000-6000 ft. [Europe and N. America.]

31. *Syrphoctonus ornatus* (Grav.), Ichn. Eur. 3 : 340 (1829) (*Bassus*); FBI, 3 : 285 (1913) (*Homocidus*)
*Kangra Valley.

32. *Theronia maculipes* (Morl.), FBI, 3 : 148 (1913) (*Orientotheronia*)
*Kangra Valley 4500 ft. [Bombay; Poona; Ceylon; Tenasserim; Merguli; Singapore.]

Family STEPHANIDAE

33. *Foenatopus iridipennis* Elliott, Entom. 52 : 30 (1911); Cat. Indian Ins., 10 : 8 (1926)
*Kangra, 4000 ft. [Dehra Dun.]

Superfamily *SERPHOIDEA*

Family SCELIONIDAE

34. *Microphanurus barrowi* (Dodd), Trans. R. ent. Soc. 1919 : 356 (1920) (*Telonomus*); Cat. Indian Ins., 26 : 16 (1941)
*Dalhousie.

35. *Telonomus sagei* Mani, R. I. M., 38 : 335 (1936); Cat. Indian Ins, 26 : 13 (1941).
*Dharmsala.

Superfamily *FORMICOIDEA*

Family FORMICIDAE

36. *Aphaenogaster* (*Aphaenogaster*) *cristata* Forel, Rev. Suisse Zool., 10: 225 (1902); FBI, 2 : 276 (1903)
*Dharmsala.

37. *Aphaenogaster* (*Aphaenogaster*) *rothneyi* Forel, Rev. Suisse Zool., 10 : 224 (1902); FBI, 2 : 273 (1903)
N. W. Himalayas to Sikkim. [Mussurie; Darjiling; Pachmarhi (Central India).]

38. *Aphaenogaster* (*Apahaenogaster*) *sagei* Forel, Rev. Suisse Zool., 10 : 221 (1902); FBI, 2 : 275 (1903)
*Lahoul, extending into Tibet.

39. *Aphaenogaster* (*Aphaenogaster*) *smythiesi* Forel, Rev. Suisse Zool., 10 : 222 (1902); FBI, 2 : 276 (1903)
N. W. Himalayas.

40. *Camponotus* (*Camponotus*) *basalis* Smith, 2nd. Yark. Miss., p. 9 (1878); FBI, 2 : 352 (1903)
*Kashmir.

41. *Camponotus* (*Camponotus*). *buddhae* Forel, JBNHS, 7 (1892); FBI, 2 : 359 (1903)
*Lahoul, frontior of Tibet.

42. *Camponotus* (*Componotus*) *delendus* Forel, JBNHS, 7 : 227, 238 (1892) (*C. rufoglaucus delendus*), FBI, 2 : 364 (1903).
*N. W. Himalayas above 5000 ft. [Sikkim.]

43. *Camponotus* (*Camponotus*) *marginatus* (Latr.), Ess. Hist. Fourm. Fr., p. 35 (1798) (*Formica*); FBI, 2 : 369 (1903)
N. W. Himalayas. [Europe and America.]

44. *Cremastogaster* (*Cremastogaster*) *buddhae* Forel, Rev. Suisse Zool, 10 : 206 (1902); FBI, 2 : 132 (1903). *N. W. Himalayas.

45. *Cremastogaster* (*Cremastogaster*) *himalayana* Forel, Rev. Suisse Zool., 10 : 202 (1902); FBI, 2 : 143 (1903). *N. W. Himalayas.

46. *Cremastogaster* (*Cremastogaster*) *perelegans* Forel, Rev. Suisse Zool., 10 : 202 (1902); FBI, 2 : 142 (1903). *N. W. Himalayas. [Punjab; Poona; Tenasserim, Ataran Valley.]

47. *Cremastogaster* (*Cremastogaster*) *sagei* Forel, Rev. Suisse Zool., 10 : 204 (1902); FBI, 2 : 135 (1903) The Himalayas from *Dharmsala to Sikkim, 2000-7000 ft.

48. *Formica* (*Formica*) *fusca* Linn., Syst. Nat. ed. 10 : 580 (1758); FBI, 2 : 336 (1903). *Himalayas, hills north of Mussurie [Sikkim; C. P; Europe; N. Africa; N. Asia; N. America.]

49. *Formica* (*Formica*) *gasgates* Latr., Ess. Hist. Fourm. Fr., p. 36 (1798); FBI, 2 : 336 (1903).
*Lahoul, frontior of Tibet border. [Northern and Central Europe; N. Asia & N. America.]

50. *Formica* (*Formica*) *rufibarbis* Fabr., Ent. Syst., 2 : 355 (1793); FBI, 2 : 335 (1903)
*Lahoul; *Dharmsala; Himalayas over 10,000 ft. [Sikkim; Europe & N. America.]

51. *Formica* (*Formica*) *sanguinea* Latr., Ess. Hist. Fourm. Fr., p. 37 (1798); FBI, 2 : 336 (1903).
*Lahoul, frontior of Tibet. [N. Europe, Asia and America.]

52. *Formica* (*Formica*) *truncicola* Nyl., Acta Sc. France, 2 : 907 (1847); FBI, 2 : 234 (1903).
*Lahoul on the frontior of Tibet. [Widespread in Northern and Central Europe and Northern Asia]

53. *Lasius* (*Lasius*) *alieno-brunneus* Forel, J. B. N. H. S., 8 : 404 (1894) (*L. nigar alino-brunneus*); FBI, 2 : 340 (1903).
*N. W. Himalayas, 6000-9000 ft.

54. *Lasius* (*Lasius*) *alieno-flavus* Bingham, FBI, 2 : 341 (1903) Himalayas above 8000 ft.
55. *Lasius* (*Lasius*) *alienus* (Fōr), Hym, Stud., 1 : 36 (1850) (*Formica*); FBI, 2 : 342 (1903).
    *N. W. Himalayas to 9000 ft. [Europe and America]
56. *Lasius* (*Lasius*) *crinitus* (Smith), Cat. 6 : 13 (1858) (*Formica*); FBI, 2 : 339 (1903).
    *Kashmir.
57. *Lasius* (*Lasius*) *himalayanus* Forel, JBNHS, 8 : 404 (1894) (*L. niger himalayanus*); FBI, 2 : 340 (1903). *N. W. Himalayas, 6000-9000 ft.
58. *Leptothorax* (*Leptothorax*) *fultoni* Forel, Rev. Suisse Zool., 10 : 229 (1902); FBI, 2 : 216 (1903)
    *Dharmsala.
59. *Leptothorax* (*Leptothorax*) *inermis* Forel, Rev. Suisse Zool. 10 : 229 (1002); FBI, 2 : 215 (1903)
    *Dharamsala.
60. *Leptothorax* (*Leptothorax) rothneyi* Forel, Rev. Suisse Zool., 10 : 230 (1902); FBI, 2 : 217 (1903). *North-West Himalayas. [Mussurie; Sikkim; Hills of Central India, Pachmarhi.]
61. *Messor* (*Messor*) *barbarus* (*Linn.*), Syst. Nat. ed. 12 (1) : 962 (1767); FBI, 2 : 278 (1903). *N. W. Himalayas. [Cochin.]
62. *Messor* (*Messor*) *himalayanus* (Forel), Rev. Suisse Zool., 10 : 220 (1902) (*Stenamma* (*Messor*) *barbarum himalauanum*); FBI, 2 : 279 (1903).
    *Dharmsala. [Tons Valley; Quetta.]
63. *Monomorium* (*Monomorium*) *atomus* Forel, Rev. Suisse Zool., 10 : 210 (1902); FBI, 2 : 208 (1903). *N. W. Himalayas. [Bengal; W. India: Poona; Assam]
64. *Monomorium* (*Monomorium*) *orientale* Mayr, Verh. zool. bot. Ges. Wien. 28 : 670 (1878); FBI, 2 : 207 (1903). *N. W. Himalayas. [Bengal; Shan States, Burma.]
65. *Monomorium* (*Monomorium*) *sagei* Forel, Rev. Suisse Zool., 10 : 211 (1902); FBI, 2 : 208 (1903).
    *Dharamsala.
66. *Myrmica* (*Myrmica*) *rugosa* Mayr, Nov. Reise Zool. Formid. p. 19 (1865); FBI, 2 : 268 (1903). The Himalayas above 4000 ft.
67. *Myrmica* (*Myrmica) smytheisi* Forel, Rev. Suisse, Zool., 10: 266 (1902); FBI, 2 : 269 (1903). N. W. Himalayas above 7000 ft. [Sikkim above 4000 ft.]
68. *Phidole* (*Phidole*) *himalayana* Forel, Rev. Suisse Zool., 10 : 185 (1902); FBI, 2 : 265 (1903). Himalayas from *Kashmir to Sikkim.
69. *Phidole* (*Phidole*) *templaria* Forel, Rev. Suisse Zool., 10 : 174 (1902); FBI, 2 : 244 (1903). *N. W. Himalayas, Nissor. [Sikkim, 6000 ft.]

70. *Phidole* (*Phidole*) *sagei* Forel, Rev. Suisse Zool., 10: 174, 192 (1902); FBI, 2 : 243 (1903).
*Dharmsala.

71. *Tetramorium salvatum* Forel, Rev. Suisse Zool., 10 : 235 (1902); FBI, 2 : 180 (1903). *N. W. Himalayas. [W. India.]

Superfamily *CHRYSIDOIDEA*
Family Chrysididae

72. *Chrysis* (*Chrysis*) *bahadur* Nurse, Entom., 36 : 11 (1903) ; FBI, 2 : 473 (1903).
*Kashmir, 6000-8000 ft.

73. *Chrysis* (*Chrysis*) *kashmirensis* Nurse, Entom., 35 : 307 (1902); FBI, 2 : 441 (1903).
*Kashmir, 5000-6000 ft.

74. *Elampus kashmirensis* Nurse, Entom., 35 : 305 (1912); FBI, 2 : 420 (1903) (*Ellampus*)
*Kashmir, 5000 ft.

75. *Holopyga cupreata* Nurse, Entom., 35 : 305 (1902); FBI, 2 : 423 (1903).
*Kashmir, 5000-6000 ft.

Superfamily *SPHECOIDEA*
Family Bembicidae

76. *Bembix latitarsus* (Handl.), Sitz. Akad. Wiss. Wien., 102: 707 (1893); FBI, 1 : 289 (1897) (*Bembex*).
*N. W. Himalayas, Gilgit. [Mussurie]

77. *Bembix trepanda* (Dahlb.), Hym. Eur., 1 : 181, 490; FBI, 1 : 228 (1897) (*Bembex*).
*Gilgit. [Bombay, Ceylon, extending upto Malayan region.]

Family Crabronidae

78. *Crabro elongatus* Nurse, JBNHS, 15 : 18 (1903)
*Kangra Valley : Holta, 4500 ft.

Family Dimorphidae

79. *Astata kashmirensis* Nurse, JBNHS, 19 : 551 (1909)
*Kashmir, 5000-6000 ft.

Family Pemphredonidae

80. *Passaloecus dudgeoni* Nurse, J. B. N. H. S., 15 : 12 (1903)
*Kangra Valley, 45000 ft.

81. *Stigmus cuculus* Nurse, JBNHS, 15 : 12 (1903)
*Kangra Valley, Holta.

Superfamily *SCOLIIODEA*

Family Scoliidae

82. *Scolia* (*Scolia*) *haemorrhoidalis* Fabr., Mant., 1 : 280; FBI, 1 : 77 (1897)
*Kashmir. [S. Europe; Karachi; Persia.]

Superfamily *VEPOIDEA*

Family Eumenidae

83. *Eumenes quadrispinosa* Sauss., Mon. Guep. Sol. Suppl., p. 134; FBI, 1 : 336 (1897).
*N. W. Himalayas. [Mussurie; Sikkim; Calcutta; Central India; Madras; Burma, Tenasserim.]

84. *Rynchium flavomarginatum* (Smith), Trans. ent. Soc., p. 35 (1852); FBI, 1 : 359 (1897) (*Rhynchium*).
*N. W. Himalayas. [Mussurie; Sikkim; Calcutta.]

Superfamily *APOIDEA*

Family Andrenidae

85. *Andrena cineraria* (Linn.), JBNHS, 15 : 557 (1904)
*Kashmir.

86. *Andrena convexicula* (Kirby), JBNHS, 15 : 557 (1904)
*Kashmir.

87. *Andrena floridula* Smith, 2nd Yark. Miss., p. 2, fig. 4; FBI, 1 : 444 (1897).
*Ladak : Drás, Kárgil and Leh.

88. *Andrena pilipes* (Fabr.), J. B. N. H. S., 15 : 557 (1904).
*Kashmir.

Family Anthophoridae

89. *Anthophora confusa* Smith, Cat. 2 : 337; FBI, 1 : 528 (1897)
*Ladak (?). [Barrakpore; Sikkim; Bombay; Burma.]

90. *Anthophora vedettus* (Nurse), JBNHS, 15 : 582 (1904) (*Podalirius*)
*Kashmir, 5000 ft.

91. *Eucera diana* Nurse, JBNHS, 15 : 579 (1904)
*Kashmir, 5000 ft.

Family Apidae

92. *Apis dorsata* Fabr., Ent. Syst. 2 : 328; FBI, 1 : 557 (1897).
Through-out India including *N.W. Himalayas and Kashmir. [Burma ; China, Ceylon, and Malayan region to Java.]

93. *Apis florea* Fabr., Mant. Ins. 1 : 305; FBI, 1 : 559 (1897).
Throughout India including *N. W. Himalayas. [Burma, Ceylon, extending in the Malayan region as far as Java.]

94. *Apis indica* Fabr., Ent. Syst. Suppl., p. 274; FBI, 1 : 558 (1897).
Throughout India including *Kashmir and N. W. Himalayas.

[Burma; Ceylon; extending into China and the Malayan region to Java.]

Family BOMBIDAE

95. *Bombus longiceps* Smith, 2nd Yark. Miss., p. 8; FBI, 1 : 555 (1897).
*Ladak : *Drás, *Kárgil & *Leh.

96. *Bombus melanurus* Leppel., Hist, nat. Ins. Hym., p. 469; FBI, 1 : 550 (1897).
*Ladak : Pangong Valley. [Syria; Siberia.]

97. *Bombus vallestris Smith,* 2nd Yark. Miss. p. 8 ; FBI, 1 : 553 (1897).
*Ladak : *Dras; *Kargil, *Leh. [Sikkim above 7000 ft.]

Family COLLETIDAE

98. *Hylaeus fervida* (Smith), 2nd Yark. Miss. p. 1 (*Prosopis*); FBI, 1 : 412 (1897) (*Prosopis*)
*Kashmir : Sind Valley.

Family MEGACHILIDAE

99. *Megachile vigilans* Smith, 2nd. Yark. Miss. p. 5 ; FBI, 1 : 488 (1897)
*Ladak. [Sikkim; Ceylon; Tenasserim].

100. *Osmia adae* Bingham, FBI, 1 : 468 (1897).
*N. W. Himalayas. [Kumaon.]

Family NOMADIDAE

101. *Nomada (Nomada) annexa* Nurse, JBNHS, 15 : 572 (1904)
*Kashmir, 5000-6000 ft.

Family NOMIIDAE

102. *Nomia (Nomia) kangrae* Nurse; JBNHS, 15 : 569 (1904) *Kangra Valley, 4500 ft.

Family POMPILIDAE

103. *Pompilus moestus* Bingham, FBI, 1 : 163 (1897)
*Ladak : Drás, Kárgil & Leh.

Order DIPTERA

Family ITONIDIDAE

1. *Acroectasis campanulata* Mani, Agra. Univ. J. Res. (Sci.) 3 (1) : 17-19, 29, pl. vii (1954).
*Dalhousie, 8000 ft. Dhauladhar Ranges.

2. *Kiefferia pimpenellae* (F. Löw) Verh. zool.—bot. Ges. Wien, 24: 326 ( ).
*Upper Sutlej Valley, Main Himalayas, 9000 ft. [Narkanda 9500 ft. Simla Hills; Chakrata Ranges, Garhwal Himalayas 7000 ft. Also throughout Europe.]

3. *Neolasioptera* sp. Mani, Agra Univ. J. Res. (Sci.) 3 (1) : 16 (1954).
   *Dharmsala : Kangra Valley, Dhauladhar Ranges 5000-6000 ft.
4. *Oxasphondylia dosua* Mani, Agra Univ. J. Res. (Sci.) 3 (1) : 22 (1954).
   *Dharmsala : Kangra Valley, 6000-8000 ft;
   *Dalhousie, 8000 ft; Dhauladhar Ranges. [Mussurie Hills, 7000 ft., Chakrata Ranges 7000 ft. Garhwal Himalayas.]
5. *Oxasphondylia echinata* Mani, Agra Univ. J. Res. (Sci)3 (1) : 20 (1954).
   *Kareiri 8000 ft., *Dharmsala, Kangra Valley; *Dalhousie 8000 ft. Dhauladhar Ranges.
6. *Oxasphondylia floricola* Mani, Agra Univ. J. Res. (Sci.) 3 (1) 25 (1954).
   *Dalhousie : Dhauladhar Ranges.
7. *Rhopalomyia* sp. *Upper Sutlej Valley ; [Garhwal Himalayas; [Kumaon Himalayas.]
8. *Rhopalomyia* sp. Mani, Agra Univ. J. Res. (Sci) 3 (1) : 15 (1954).
   *Dalhousie 8000 ft. Dhauladhar Ranges.
9. *Rhopalomyia millefolii* (H. Löw) Dipt. Beitr. 1 : 37 (1850); Mani, Agra Univ. J. Res. (Sci.) 3 (1) : 15 (1954).
   *Dalhousie, 8000 ft. Dhauladhar Ranges [Persia, Europe, Egypt].

Order THYSANURA

Family Lepismidae

1. *Ctenolepisma longicaudata* Easch., Mem. Conn. Acad. Art & Sci., 10 : 251 (1936).
   *Cliff above Wakka Chu River, near Kargil, 2740 m. [Africa and Asia.]
2. *Ctenolepisma sp.* Mem. Conn. Acad. Art & Sci., 10 : 258 (1936)
   *Between Lehand Spitok (Spithug) at about 3350 m.
3. *Ctenolepisma* sp. Mem. Conn. Acad. Art. & Sci., 10 : 258 (1936)
   Camp below *Anem La 5315 m.

Family Machilidae

4. *Mechilanus hutchinsoni* Silv., Mem. Conn. Acad. Art. & Sci., 10 : 259 (1936).
   Camp below *Anem La 5315 m., Slope opposite *Mulbe Gompa.

Order APTERA

Family Campodeidae

1. *Lepidocampa weberi* Oud., Mem. Conn. Acad. Art. & Sci., 10 : 253 (1936).
   *Kanyan, Kashmir, 1810 m., Takhat-i-Sulaiman, Srinagar, 1645 m.

Family JAPYGIDAE

2. *Indjapyx petrunkevitchi* Silv., Mem. Conn. Acad. Art. & Sci., 10 : 255 (1936).
   *Takhat-i-Sulaiman, Srinagar, 1585 m.

Order COLLEMBOLA

Family HYPOGASTRURIDAE

1. *Friesea excelsa* Denis, Mem., Conn. Acad. Art. & Sci., 10 : 261 (1936).
   *Ororotse La, top, 5500 m.
2. *Hypogastrura armata* (Nic), Mem. Conn. Acad. Art. & Sci., 10 : 261 (1936). Edge swamp, *Phashakuri near Pampur. [Cosmopolitan.]
3. *Hypogastrura communis* (Folsom), Mem. Conn. Acad. Art. & Sci., 10 : 261 (1936).
   *Gagirbal, 1580 m. Swampy pond. [Formosa, China, Japan.]
4. *Neanura intermedia* Imms, Proc. Zool. Soc. Lond., p. 87, pl. vi, vii, figs. 13, 14 (1912). Near Bhowali, Nainital District in the Himalayan foot hills of Kumaon, 5000 ft.
5. *Xenylla obscura* Imms, Proc. Zool. Soc. Lond., p. 84, pl. vi, figs. 5-9 (1912). Simla, 7000 ft. (W. Himalayas)

Family ISOTOMIDAE

6. *Isotoma siva* Imms, Proc. Zool. Soc. Lond., p. vi, vii fig. 16, 18, 19 (1912) Under stones along the edge of a mountain stream at Badrinath, Garhwal Himalayas.
7. *Isotoma spinicauda* Bonet, Mem. Conn. Acad. Art. & Sci., 10 : 263 (1936).
   *Nyag-tzu, lower camp, Ladak, dry bank; *Ororostse-la, south side, 5300 m. [Wazirastan near Afganistan Border.]
8. *Proisotoma ladaki* Denis, Mem. Conn. Acad. Art. & Sci., 10 : 262, 282 (1936).
   *Mitpal Tso, North edge, Togarma Tso.

Family MYDONIIDAE

9. *Dicranocentroides fasciculatus* Imms, Proc. Zool. Soc. London, p. 102, pl. viii, ix, x, figs. 45, 57, 55, 55a, 68 (1912) Under the damp dead leaves chiefly of Quercus, in forest at Bhowali, Himalayan foot hills of Kumaon, 5700 ft.
10. *Drepanosira subornata* (Denis), Mem. Conn. Acad. Art. & Sci., 10 : 267 (1936) (*Parasira*).
    *Dambu—guru, Ladak, 4603 m., dry bank; *Takht-i-Sulaiman, Srinagar, 1585 m.

11. *Lepidocyrtinus unifasciatus* Denis, Mem. Conn. Acad Art. & Sci. 10 : 269 (1936). Edge of Phashakuri, near *Prmpur, 1595 m.

12. *Mydonius crassa* (Imms), Proc. Zool. Soc. London, p. 95, pl. vii, figs. 30, 31 (1912) (*Entomobrya*). In ant's nest undér stones about half a mile below the base of Satopanth Glacier, Garhwal Himalaya, 12500 ft.

13. *Mydonius himalayensis* Baijal, Agra Univ. J. Res. (Sc.), 4 (1) : 176, fig. 5-8 (1955).
*On glaciers and streams below glaciers near Thirot, 9500-11000 ft. Main Himalayas, Upper Chenab Valley.

14. *Mydonius hutchinseni* (Denis), Mem. Conn. Acad. Art. & Sci., 10 : 282 (1936) (*Entomobrya*).
*Shakya La, Indian Tibet, east side, talus slope, 5440 m.

15. *Mydonius kali lutea* (Imms.), Proc. Zool. Soc. London, p. 96 (1912) (*Entomobrya*). Among low herbs and grass at Simla, 7000 ft.

16. *Orchesellides boraoi* Bonet, Mem. Conn. Acad. Art. & Sci., 10 : 263, 282 (1936).
*East of Shakya la, 5200 m. Ororostse-la, South side, 5300 m. Marsimik la, under stones, 5600; Orortse-Tso, 5513 m. [Wazirastan, 1000 m.]

17. *Paronella gracilis* Imms, Proc. Zool. Soc. London, p. 109, pl. xi, figs. 77, 78 (1912).
*Among damp dead leaves in forest of rhododendron and oak at Bhowali, Himalayas foot hills of Kumaon, 5700 ft.

18. *Paronella phanolepis* Imms, Proc. Zool. Soc. London, p. 110, pl. x, xi, figs. 69, 79 (1912).
*Inside walls of an old bungalow probably residing in decaying beams and rafters, Bhowali, Himalayan foot hills of Kumaon, 5700 ft.

19. *Seira brahamides* (Denis), Mem. Conn. Acad. Art. & Sci., 10 : 265 (1936) (*Sira*).
*Karpet, S. Shore of Panggong Tso, c. 4250 m., damp grassy place; Tang-yar, Ladak, 4400 m, under stones in stream.

20. *Seira frigida* Imms, Proc. Zool. Soc. London, p. 97 pl. viii, figs. 41, 42 (1912).
In ants's nest under stones on a mountain side a short distance below the base of the Satopanth Glacier, Garhwal Himalayas, 12,300 ft.

21. *Sinella montana* Imms, Proc. Zool. Soc. London, p. 101, pl. viii ix, figs. 48, 56, 57, 1912).
In an ant's nest under stones on a mountain side near Badrinath, Garhwal Himalaya, 10,300 ft.

Family PODURIDAE

22. *Podura himalayana* Baijal, Agra Univ. J. Res. (Sci), 4 (1) ; 175, figs. 1-5 (1955).

From glaciers and streams below glaciers, 14000 ft, *Upper Chenab Valley, Main Himalayas.

Family SMINTHURIDAE

23. *Sminthurides aquaticus* (Bourlet), Mem. Conn. Acad. Art. & Sci., 10 : 275 (1936).
    *Kyam, small spring surface at 4763 m. [Certainly exists in Europe, possibly America, Algeria, and Australia.]
24. *Bourletiella arvalis* (Fitch), Mem. Conn. Acad. Art. & Sci., 10 : 278 (1936).
    Edge of Phashakuri near *Pampur, 1585 m., Kashmir., [Europe, North America.]
25. *Sminthurides* (*Stenacidia*) *violaceus* (Reuter), Mem. Conn. Acad. Art. & Sci., 10 : 276 (1936).
    *Bao, East of Shakya La; surface of pool, 4616 m. [Rare in Europe; also known in Tibet.]

Family TOMOCERIDAE

26. *Tomocerus vulgaris* Tulb., Proc. Zool. Soc. London, p. 91 (1912).
    Edge of a mountain stream at Badrinath, Garhwal Himalayas 10,300 ft. [Europe].

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*
PART X.—ON A COLLECTION OF ICHNEUMONIDAE (*HYMENOPTERA*)

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This paper deals with a small collection of Ichneumonidae from the Himalayas. I am grateful to Dr. M. S. Mani, Professor of Zoology & Entomology, School of Entomology, Agra, for facilities, constant encouragement and guidance. The type specimens will be deposited in the National Collections of the Zoological Survey of India, Calcutta.

Subfamily OPHIONINAE

Tribe Porizonini (=Campoplegini)

1. **Hymenobosmina narkandensis**, sp. nov.

Judging from Morley's[1] inadequate description of *Hymenobosmina*, the material before me differs in the larger size, shorter antennae and in the absence of propodeal areola, but should undoubtedly be placed in this genus.

Male.—Elongated species with brilliant colouration, distinguished from all other known species by its much larger size, reddish brown compressed abdomen, and a characteristic black band along the apical portion of the abdomen (fig. 1). Body covered with dense, long pubescence. Length 18 mm, wings 11 mm, antennae 8 mm.

Head viewed from above quadrate (fig. 2), twice as broad as long, black, with long yellowish pubescence. Vertex reticulate, margined posteriorly; post-orbital space rugoso-punctate; ocelli close to the occipital margin, large, reddish-brown and shiny; interocellar space a little less than ocellocular space; front ocellar distance equal to the ocellar diameter. Viewed from front (fig. 3) three-fourths as long as wide; face with sides slightly narrowing towards clypeus; frons above antennae depressed, rugose and black; face below antennae yellow, pubescent and finely punctate. *Clypeus* yellow, not discrete from face, but anterior tentorial pits at the lateral margins of clypeus prominent. Eyes large, glabrous, slightly emarginate near the antennal sockets and reaching upto the bases of mandibles; post-orbital borders reddish-brown above and yellowish below. Mandibles stout, black basally and yellow in the middle; mandibular teeth black and subequal. Palpi yellow.

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[1] Morley, C. 1913. *Fauna Brit. India, Hymen.*, **3** : 438.

Antennae (figs. 1, 4) long, brownish-black, except for the yellow elongated spots on the scape; scape small, slightly longer than the pedicel; ring joint one; first flagellar segment equal to the 2nd and 3rd segments combined; apical segments reduced, short and slender; terminal segment not longer than the preceding one.

Thorax distinctly longer than high, black with two reddish-brown spots just above the articulation of hind coxae. *Mesonotum* entire, without any parapsidal furrows, coarsely punctate. *Scutellum* reddish-brown, subconvex, rugose, with a deep depression anteriorly separating it from the mesonotum, margined laterally by elevated ridges and covered with long pubescence; mesopleurae rugose, metapleurae reticulately rugose. *Propodeum* black, centrally depressed, reticulately sculptured, not margined posteriorly and without any areola; its spiracles oval.

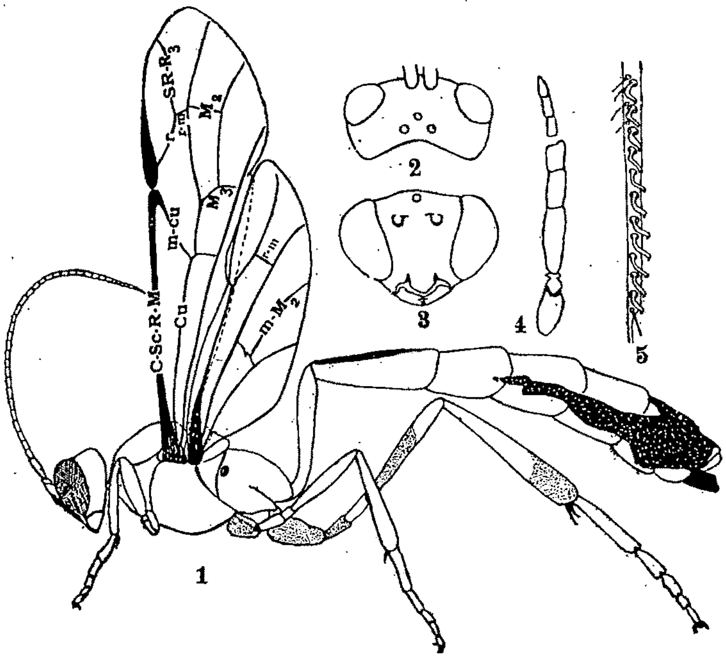

Fig. 1-5. *Hymenobosmina narkandensis*, sp. nov. Male.

1. lateral view of whole insect; 2. head viewed from above; 3. Head viewed from front; 4. antenna, basal and apical segments; 5. frenular hooks of hind wing.

Fore and *mid legs* yellowish, femora reddish-brown and coxae black; femur and coxae sparsely pubescent. *Hind* coxae swollen, twice as long as wide, black, very sparsely pubescent; proximal trochanter black, distal one reddish-brown; proximal two-thirds of femur black, rest of femur and proximal two-thirds of tibia reddish-brown; first tarsal segment equal to second, third and fourth tarsal segments combined, slightly less than half the tibia; larger tibial spur less than one-third the metatarsus and the smaller less than one-fourth the metatarsus; claw simple and slightly curved.

Wings transparent, infumate; pterostigma straminous and narrow; veins blackish; vein *r* longer than half $SR+R_3$; $SR+R_3$ slightly curved at apex and equal to *m-cu*; $m\text{-}M_2$ emerging below the middle of M_3; M_2 emerging beyond *r-m* and nearly thrice *r-m*; M_3 unpigmented near the upper half. Hind wing with 11 frenular hooks (fig. 5); M_3 sub-geniculate and intercepted below the middle. Rest of venation as in figure.

Abdomen long, about twice as long as the head and thorax combined. First abdominal segment (petiole) long and cylindrical, a little shorter than the succeeding segments, its spircales beyond the middle of the segment; rest of the segments strongly compressed. Genitalia black.

Holotype male, on pin No. 419/H; wings, hind leg and antenna of one side mounted on slide of same number; *paratype* one male, on pin No. 420/H; both labelled, "School of Entomology Expedition to Himalayas, 1954; Narkanda: Rampur Road near Sutlej Valley, 9500 ft; Coll. V. K. Gupta and J. P. Agarwal, 5-X-1954."

This species runs near to couplet No. 4 in Morley's key to Indian Species[1], but differs from *H. pilosella* Cameron and *H. mandibularis* Cameron in the absence of propodeal areola, and smaller antennae.

2. **Sinophorus collinus** Morley

1913. *Sinophorus collinus*, MORLEY, *Fauna Brit. India, Hymen.*, **3** : 478.

Morley's description of this species from a single female is incomplete.

Female.—Black, covered with whitish pubescence; abdomen reddish-brown in the middle; legs partly testaceous. Length 7 mm, antennae 5 mm and fore wing 5. 5 mm.

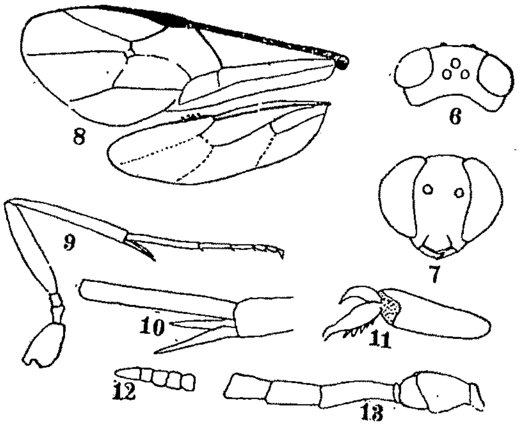

Fig. 6-13. *Sinophorus collinus* Morley. Female.
6. head viewed from above; 7. head viewed from front; 8. wings; 9 hind leg; 10. hind tibial spurs and first tarsal segment; 11. claw; 12. apical segments of antenna; 13. basal segments of antenna.

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[1] MORLEY, C. 1913. *Fauna Brit. India, Hymen.*, **3** : 439.

Head viewed from above (fig. 6) transverse nearly thrice as wide as long, slightly wider than thorax between tegulae. Vertex black, finely rugose near the ocelli and shagreened in the ocellocular region. Occiput finely rugose, with some longitudinal striations. Post-occipital region slightly pubescent. Ocelli brown; inter-ocellar space a little more than ocellocular space; ocellar diameter equal to the ocellocular and front ocellar distances; inter-ocellar space more densely rugose than the rest of the vertex. Viewed from front (fig. 7) four-fifths as long as broad, sparsely pubescent. Frons between median ocellus and antennal sockets depressed, rugose; face below antennae rugoso-punctate and densely pubescent. *Clypeus* not discrete at the base, slightly raised in the middle, evenly rounded at the apex. Mandibles brownish apically, teeth equal.

Antennae inserted slightly above the middle of face, blackish and shorter than the body; scape small somewhat globular; pedicel not longer than thick; ring joint one, small; flagellum with 34 segments; first segment equal to scape and pedicel combined, longer than the second flagellar segment and slightly shorter than the second and third combined; terminal segment (fig. 12) longer than the preceding.

Thorax black, covered with white pubescence, slightly raised above the level of head; one and one-third as long as high. *Mesonotum* entire, uniformly aciculately punctate, without any parapsidal furrows. *Scutellum* raised above the level of mesonotum, nearly pyramidal and finely rugose, sparsely pubescent. *Propodeum* not margined posteriorly, densely pubescent laterally and very sparsely dorsally, rugoso-punctate, the base very finely rugose, central portion near the base trans-rugose; propodeal spiracles oval, small.

Fore leg black-testaceous, its tibiae and tarsi much lighter than the coxa and femur. *Mid leg* black-testaceous uniformly except for the distal tarsi. *Hind leg* (fig. 9) blackish, its coxa swollen and a little elongate, pubescent and uniformly shallowly punctate; a few oblique striations on the trochanter and basal one-fourth of femur on the outer side; tibia a little smaller than the femur and longer than the tarsi; first tarsal segment nearly equal to the rest of tarsal segments combined (excluding claw); larger tibial spur (fig. 10) longer than half the metatarsus, smaller tibial spur less than half the metatarsus; claw (fig. 11) pectinate.

Wings hyaline, nervures deep brown. Pterostigma narrow, translucent, emitting vein *r* from near its centre; vein *r* just shorter than half $SR+R_3$; areolet petiolated, petiole of areola a little less than the width of areolet; M_2 unpigmented near the basal half (fig. 8); m-M_2 emerging slightly below the middle of M_3. Hind wing (fig. 8) with apical veins obsolete; four frenular hooks. Rest of the venation as in figure.

Abdomen a little longer than the head and thorax combined; first abdominal segment black, narrow and cylindrical, dilated near the spiracles which are beyond the middle of segment; second abdominal segment not strongly compressed, shorter than the first, its tergite black and sternite dirty yellow; apex of second and the whole of third, fourth and fifth segments reddish-brown, smooth with short pubescence, compressed; rest of the apical segments black and compressed; ovipositor small.

Male.—Length 7.3 mm, antenna 6 mm, fore wing 5.5 mm. Head and thorax black. Abdomen basally black and rest light reddish-brown.

Head viewed from above (fig. 16) transverse, black, pubescent, two and one-half as broad as long; inter-orbital distance equal to the length of head. Vertex finely rugose; post-orbital area rugulose; occiput pubescent laterally. Ocelli light reddish-brown, shiny; inter-ocellar distance twice the ocellocular distance; front ocellar and ocellar diameter equal to ocellocular distance. Viewed from front (fig. 15) nearly three-fourths as long as wide; face finely rugoso-punctate, the region between median ocellus and antennal sockets depressed and sparsely pubescent near the ocellus; face between antennal sockets and clypeus densely pubescent, rugulose; gena finely rugulose. *Clypeus* not discrete from face, its margin slightly curved. Eyes dark brownish-black, bare, slightly emarginate next the scrobes. Mandibles broad, yellowish, teeth brownish.

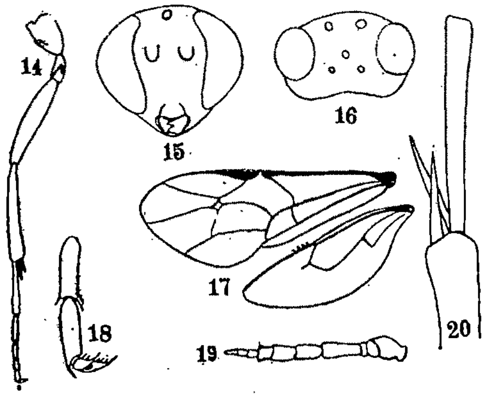


Fig. 14-20. *Sinophorus collinus* Morley. Male.

14. hind leg; 15. head viewed from front; 16. head viewed from above; 17. wings; 18. apical tarsal segments and claw; 19. antenna, basal and apical segments, 20. hind tibial spurs and first tarsal segment.

Antennae inserted slightly above the middle of face, black-testaceous, slightly smaller than the body; scape small; pedicel half the scape and followed by a ring joint; flagellum with 37 segments; first flagellar segment (fig. 19) longer than the second, but smaller than the second and third combined; terminal segments as in fig. 19.

Thorax black, somewhat pubescent dorsally, more pubescent laterally, three-fifths as high as long. *Mesonotum* rugoso-punctate, arched above and slightly above the level of head, sparsely pubescent, parapsidal furrows absent. *Scutellum* a little convex, somewhat triangular and rugoso-punctate, pubescent apically, anterior carinae of scutellum reaching upto its middle. *Propodeum* with same punctation as on mesonotum and scutellum with slight indication of a transverse arched carina near the base and a faint median carina prominent only basally; pubescent only postero-laterally; its spiracles small and nearly circular.

Fore and *mid* coxae black, pubescent and globose; rest of fore leg yellowish-testaceous; mid femur light reddish-brown; tibia and tarsi yellowish-brown. *Hind leg* (fig. 14) with coxae elongate, width nearly two-thirds the length, densely pubescent outwardly and more or less smooth and shiny on the inner side; trochanters black; femur yellowish-brown, slightly smaller than tibia; tibia and tarsi yellowish with blackish tinge; tibia equal to three basal tarsal joints; metatarsus equal to second, third and fourth tarsal joints combined and nearly half the tibia; larger tibial spur (fig. 20) slightly more than half the metatarsus while the smaller tibial spur is nearly two-fifths the metatarsus (fig. 18); claws pectinate.

Wings (fig. 17) hyaline, pterostigma and veins dark testaceous. Pterostigma somewhat narrow, emitting vein *r* slightly below the middle; areolet shortly petiolate and small; *r* longer than half $SR+R_3$; M_3 intercepted in the middle. Hind wing with four frenular hooks; apical veins obsolete; M_4-Cu_1 straight and not intercepted. Rest of the venation as in fig. 17.

Abdomen nearly one and one-third the length of head and thorax combined, somewhat compressed; first abdominal segment black, compact, dilated behind the spiracles; second segment black, except apically, depressed and two-thirds the first ; rest of the segments rather slightly compressed, rounded in appearance and reddish-brown; tip of the abdomen and genitalia black.

The male differs from female in its shortly petiolated areolet, vein *r* slightly more curved at base and longer than half $SR+R_3$, M_3 intercepted in the middle and in the reddish-yellow hind tibia and femur.

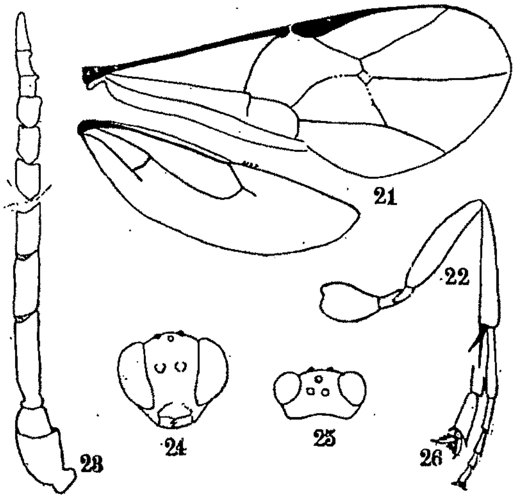
Redescribed from one female on pin No. 418/H; its wings, antenna and hind leg of one side mounted on slide of same number; labelled, "School of Entomology Expedition to Himalayas, 1954; Narkanda: Rampur Road near Sutlej Valley, 9500 ft; Coll. V. K. Gupta and J. P. Agarwal, 5-X-1954," and a male on pin No. 415/H; its wings, antenna and hind leg mounted on slide of same number; collected from same locality by M. Vishwanath and J. P. Agarwal, 5-X-1954.

The female of this species has previously been recorded from Simla only. The male has not been previously known.

3. *Sinophorus* sp. (Figs. 21-26)

To this species I refer one male, on pin No. 417/H; wings, antenna and hing leg of one side mounted on slide of same number; labelled, "School of Entomology Expedition to Himalayas, 1954; Narkanda: Ridge west of Rest House, 9500 ft; V. K. Gupta Coll., 3-X-1954."

This species does not resemble the other known Indian species and seems to be new. Small, black with legs partly testaceous. The abdomen apically rather strongly compressed and appeared club shaped in the lateral view. Abdomen accidently lost.



Figs. 21-26. *Sinophorus* sp. 21. wings; 22. hind leg; 23. antenna, basal and apical segments; 24. head viewed from front; 25. head viewed from above; 26. claw.

Tribe Cremastini

4. **Cremastus noxiosus** Morley var. **himalayana,** nov.

Female.—Bright flavous, small species with black spots on the head, thorax, propodeum and basal abdominal segments. Body 8 mm, antennae 5 mm, ovipositor 3 mm and fore wing 4 mm.

Head viewed from above (fig. 33) transverse, one and one-half as wide as thorax between tegulae, nearly two and one-half as broad as long. Ocelli large, brownish, enclosed within a black patch; inter-ocellar distance one and one-half the ocellocular distance; ocellar diameter and front ocellar distances equal to ocellocular space. Vertex very finely punctate; occiput shagreened and shiny. Viewed from front (fig. 32) one and one-fourth as broad as long, finely punctate; frons depressed, the black patch enclosing the ocelli extending upto the anterior face of the antennal sockets. Eyes nearly parallel sided internally, large and nearer the bases of mandibles. *Clypeus* apically rounded, finely punctate, somewhat discrete; epistomal suture distinct only laterally and not basally. Apices of mandibles black, with subequal teeth.

Antennae inserted near the middle of face, slender and somewhat shorter than body, darker, with 38 segments; scape globular, with a black patch on the anterior side; first flagellar segment (fig. 29) equal to the scape and pedicel combined, slightly longer than the second; basal flagellar segments cylindrical; segments 30-37 (fig. 31) not longer than thick; terminal segment (fig. 31) elongate and thick, equal to two preceding segments.

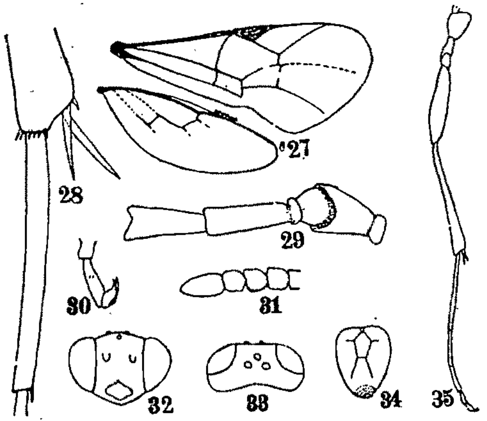


Fig. 27-35. *Cremastus noxiosus himalayana*, var. nov. Female.

27. wings; 28. hind tibial spurs and first tarsal segment; 29. basal segments of antenna; 30. claw; 31. apical antennal segments; 32. head viewed from front, 33. head viewed from above; 34. propodeum; 35. hind leg.

Thorax stout, longer than high, dorsal surface arched and slightly raised above the level of head. *Mesonotum* finely rugose, parapsidal furrows absent; one broad brownish-black stripe in the anterior mid-dorsal region and two on the posterior lateral regions of the mesonotum. *Scutellum* subconvex, clear yellow, sparsely punctulate and somewhat shiny; small black patches surrounding the scutellum; Anterior carinae of scutellum reaching upto its base. Mesopleurae evenly and distinctly punctulate. *Propodeum* (fig. 34) elongate and oval in shape, transrugose, the transverse striae more prominent in the apical half; a black patch on the basal mid-dorsal region of the propodeum; propodeal areola pentagonal, twice as long as broad, issuing transverse costulae above the middle, sparsely pubescent laterally; propodeal spiracles small and sub-circular.

Fore and *mid legs* golden yellow, their coxae globose and apices of tarsi and claw blackish. *Hind leg* (Fig. 35) elongated; its coxa pale, and equal to both trochanters combined; femur golden yellow; tibia and tarsi darker; tibia longer than femur and equal to three proximal tarsal joints combined; metatarsus equal to the rest of tarsal joints; tarsal spurs (Fig. 28) sub-equal, the longer one-third the metatarsus; claw (Fig. 30) simple.

Wings hyaline, nervures yellowish-testaceous. Fore wing with no areolet; pterostigma broad and sub-triangular, emitting vein *r* from its centre; radial cell short; vein *r-m* two-fifths M_2; vein *r* more than half $SR+R_3$; M_2 emitted just beyond *r-m*; R_{4+5}-M_1 and m-M_2 obsolete apically; M_3 intercepted above the middle. Hind wings with six frenular hooks, apical veins obsolete; M_4-Cu_1 not intercepted and nearly straight. Rest of the venation as in fig. 27.

Abdomen long and compressed; first abdominal segment cylindrical and elongate, its spiracles small, circular and near the apex, dilated near the spiracles, reddish-brown, with black patch on the basal and apical parts of tergite; second tergite three-fifths the first segment, reddish-brown with black patch anteriorly; rest of the abdominal segments rather strongly compressed, brownish-yellow and with sparse pubescence; the compressed parts of the tergites blackish; *ovipositor* dark brown, cylindrical and acutely pointed at the tip.

Holotype female, on pin No. 416/H, labelled, "School of Entomology Expedition to Himalayas, 1954; Narkanda: Ridge west of Rest House, 9500 ft; V. K. Gupta Coll., 3-X-1954." Hind leg, antenna and wings of one side mounted on slide of same number.

This variety differs from the typical *Cremastus noxiosus noxiosus* Morley[1] in the antennae being smaller than the body, thorax flavous, metathorax not black, areola twice as long as broad, abdomen with minute black patches only and other differences in colouration.

Tribe Ophionini

5. **Stauropoctonus orientalis** Morley

1912. *Stauropodoctonus orientalis*, MORLEY, *Revis. Ichn. Brit. Mus.*, p. 18.
1913. *Stauropodoctonus orientalis*, MORLEY, *Fauna Brit. India, Hymen.*, **3** : 376.
1947. *Stauropoctonus* Brauns=(*Stauropodoctonus* [*Sic.*] Brauns), CUSHMAN, *Proc. U. S. Nat. Mus.*, 96 : 456.

To this species I refer two females and one male on pins Nos. 423/H, 424/H & 425/H, labelled, "School of Entomology Expedition to Himalayas, 1953; Reserve Forest, Kalatop, 8000 ft., Dalhousie: Dholadhar Range (Gurdaspur Dist.), Coll. M. S. Mani & Santokh Singh, 18-VI-1953." Five of them were caught from the underside of leaf of *Vibernum cotinifolium* and when approached they made no attempt to escape.

Morley (*loc. cit.*) recorded this species from Bombay, Ceylon: Paradeniya, and Formosa.

Length 20 mm; male and female whitish straw coloured; antennae dark testaceous, longer than body; thorax with black patches on mesonotum, mesopleurae and metapleurae; sub-petiolar area of propodeum with a black patch; third abdominal segment apically and most of the fifth and sixth blackish; wings large; pterostigma pale in the basal half and black apically, a small infumate area below pterostigma; glabrous area without any cornuous alar marks.

Morley's specimens were of slightly darker colour. The present record extends its distribution to the N. W. Himalayas.

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[1] Morley, C. 1913. *Fauna Brit. India, Hymen.*, **3** : 501.

6. **Enicospilus horsfieldi** Cam.

1905. *Enicospilus horsfieldi*, CAMERON, *Spolia Zel.*, p. 124.
1913. *Henicospilus horsfieldi*, MORLEY, *Fauna Brit. India, Hymen.*, 3 : 394.

To this species I refer one female on pin No. 421/H, found dead in Akash Hotel, Simla, on 2-X-1954; M. S. Mani Coll.

The specimen before me shows some variations in characters from that given by Morley (*loc. cit.*) in which respect it approaches *E. dasychirae* Cam.[1] The vein *r-m* is equal to M_2 and not shorter—a character of *dasychirae*, but it is straight and oblique and not curved. In this latter character it approaches *horsfieldi*. Similarly the sculpture of propodeum is intermediate between these two species. The length is 27 mm, near *E. dasychirae* (21 mm). Since it exhibits most of the characters of *E. horsfieldi* it has been placed here but could well be considered an intermediate species. The specimen is partly mutilated and not fit for redescription.

Morley (*loc. cit.*) has expressed doubts regarding the identity of the above mentioned two species, and should the type specimens exhibit the characters as given in their descriptions and in view of the present specimen, *E. horsfieldi* be merged with *E. dasychirae*, the latter been described earlier in the same paper.

E. dasychirae is known from Ceylon: Pandaluoya and *E. horsfieldi* from U. P., Assam, Bengal, Bombay, Madras, Banglore and Ceylon. The present record extends its distribution to Himalayas.

Subfamily CRYPTINAE (=GELINAE)

Tribe Hemitelini

7. **Hemiteles punjabensis**, sp. nov.

Male.—Black, slender species, with only the hind femur red. Head, sides of the thorax and propodeum covered with whitish pubescence. Length 9·5 mm, antenna about 8 mm, forewing 8.5 mm.

Head viewed from above (fig. 43) nearly twice as broad as long, shiny and pubescent, nearly as wide as thorax between tegulae; inter-orbital distance half the width of head. Vertex sparsely pubescent ocellocular region glabrous; ocelli yellowish-brown, in the centre of the vertex; inter-ocellar distance a little more than ocellocular distance; ocellar diameter three-fourths, and front-ocellar distance half the inter-ocellar distance; post-orbital distance equal to the width of the eye, densely pubescent. Viewed from front (fig. 44) two-thirds as long as wide; frons between front ocellus and antennal sockets a little depressed, shiny, sparsely punctulate and pubescent; face below antennae slightly elevated in the middle, densely pubescent and somewhat shallowly punctate. The orbital borders next the antennal sockets with a yellowish-white triangular patch on either side. *Clypeus* slightly convex, sparsely pubescent, discrete from face, slightly arched basally and the apical border nearly straight. Mandibles large, covered with some stiff bristles and projecting in front of the clypeus; teeth nearly equal. Palpi conspicuous. Eyes brownish, glabrous, nearly parallel-sided internally. Genae densely pubescent.

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[1] Cameron, 1905. *Spolia Zelyanica*, p. 123.

Antennae long, longer than half the length of body; inserted in middle of face; scape and pedicel globular, three-fifths the first flagellar segment, pubescent; ring joint one; flagellum with 36 segments, first flagellar segment (fig. 42) slightly longer than the second; apical segments (fig. 41) attenuate, terminal segment longer than the preceding.

Thorax nearly two-thirds as high as long; pronotum striated laterally; *mesonotum* slightly raised above the level of head, shiny, sparsely pubescent; parapsidal furrows faintly represented; *scutellum* smooth and shiny, pubescent apically, anterior carinae of scutellum reaching upto its middle, nearly pyramidal abruptly raised from the level of mesonotum, some striations near its base; mesopleurae rugoso-striate, densely pubescent. *Propodeum* (Fig. 45) areolated; petiolar area and basal area trans-rugose; rest of propodeum rugose; areola as in figure; propodeal spiracles circular.

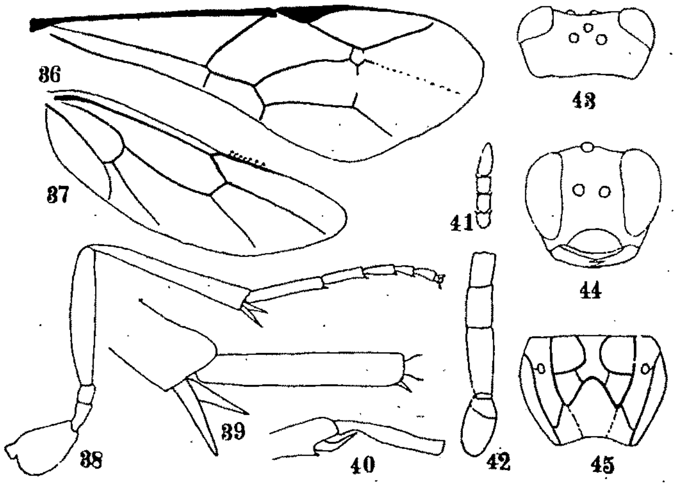

Fig. 36-45. *Hemiteles punjabensis*, sp. nov. Male.
36. fore wing; 37. hind wing; 38. hind leg; 39. hind tibial spurs and first tarsal segment. 40. tibial spur and first tarsal segment of fore leg; 41. apical antennal segments; 42. basal antennal segments; 43. head viewed from above; 44. head viewed from front; 45. propodeum.

Fore leg with brownish tinge; tibial spur one; metatarsus notched near the tibial spur (Fig. 40). *Mid leg* also with brownish tinge; tibial spurs two. *Hind leg* (fig. 38) elongated; coxa longer than the trochanters; femur reddish, four-fifths the tibia; tibia slightly more than double the first tarsal segment; tibial spurs unequal (fig. 39), larger tibial spur two-fifths and smaller tibial spur one-third the first tarsal segment; first tarsal segment equal to second and third segments combined; claw with bristles basally.

Wings hyaline, nervures blackish; fore-wing (fig. 36) with narrow, pterostigma; vein r slightly longer than half $SR+R_3$; areolet large, pentagonal open externally; veins R_3 & M_1+R_{4+5} nearly completely and M_2 partly unpigmented; M_3 intercepted slightly below the middle. Rest of the venation as in figure. Hind wing (fig. 37) with 7 frenular hooks; vein $SR+R_3$ & M_1+R_{4+5} obsolete apically; M_4-Cu_1 geniculate and intercepted below the middle. Rest of venation as in figure.

Abdomen longer than head and thorax combined, nearly smooth and pubescent; first abdominal segment basally compressed, its spiracles round and posterior to the middle of segment; rest of the abdominal segments depressed; claspers prominent.

Holotype male, on pin No. 431/H, labelled, "School of Entomology Expedition to Himalayas, 1954; Narkanda: Rampur Road, near Sutlej Valley, 9500 ft; V. K. Gupta Coll., 5-X-1954." Hind leg, antenna and wings of one side on slide of same number.

Subfamily ICHNEUMONINAE

Tribe Platylabini

8. **Platylabus vishwanathai,** sp. nov.

Female.—A medium-sized species with the head and thorax partly and the abdomen wholly reddish-brown; antennae whitish in the middle; eyes black; thorax black with scutellum yellow; legs reddish-brown. Length 13 mm, ovipositor .75 mm, antennae 8 mm and fore wing 10 mm.

Head viewed from above (Fig. 53) sub-quadrate, twice as wide as long; inter-orbital distance slightly less than half the width of head; a broad black patch along the middle of the vertex from the antennal sockets upto the occipital margin; all the ocelli within this black patch; vertex between ocelli and eyes yellow; post-orbital narrowly yellow along the eye; rest of post-orbital space brownish and sparsely pubescent; inter-ocellar space one and one-third the ocellocular space; ocellar diameter nearly equal to inter-ocellar space; post-ocellar distance nearly double the inter-ocellar space. Viewed from front (Fig. 54) as wide as long, slightly narrowing towards mouth; antennal sockets on face below the middle; frons excavate between median ocellus and antennal sockets; face below antennae deep reddish-brown, sparsely pubescent and somewhat shiny, irregularly, sparsely and shallowly punctate at some places. *Clypeus* not discrete from face, broad at apex, sparsely pubescent; anterior tentorial pits on the lateral margins of clypeus distinct. Eyes twice as long as broad, their orbits yellow margined. Mandibles black at the apical one-third, teeth unequal. Maxillary palpi five jointed, yellowish, second joint dilated and flat. Labial palpi four jointed, darker than maxillary palpi.

Antennae long, longer than the head and thorax combined; scape reddish-brown, somewhat elongate and swollen; pedicel short and ring joint very thin.

First flagellar segment (fig. 51) longer than the second, about two-thirds the second and third combined. Antennae blackish-brown at the base, whitish in the middle and black towards the apex. Apical segments attenuate (Fig. 50).

Thorax long, somewhat cylindrical, length more than twice the hight; pronotum yellowish dorsally; *mesonotum* shallowly punctate, entire, without any parapsidal furrows, black except for two yellowish stripes in place of parapsidal furrows; *scutellum* flat and broadly triangular, flavous, sparsely pubescent and somewhat shiny; anterior carinae of scutellum reaching beyond its middle; meso- and metapleurae densely pubescent; mesopleurae reddish-yellow ventrally, rest black, trans-rugose; metapleurae reddish-yellow near the middle, shallowly punctate. *Propodeum* well areolated (fig. 55); petiolar area black and trans-carinate; rest of propodeum reddish-brown near the middle and yellowish at other places; basal area and areola shiny; lateral area strongly coarsely rugoso-punctate; propodeal spiracles linear and elongate; sides of propodeum covered with long dirty-white pubescence.

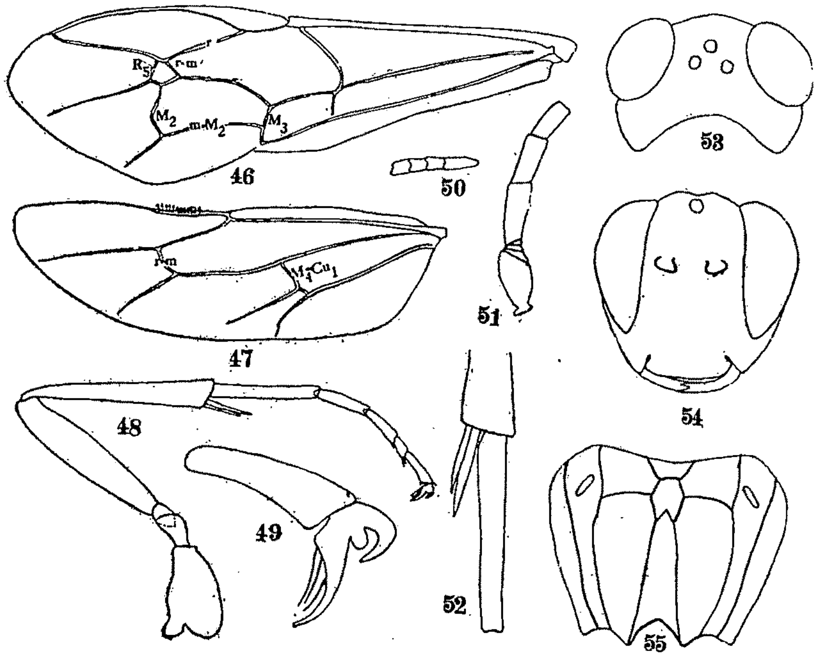

Fig. 46-55. *Platylabus vishwanathai*, sp. nov. Female.
46. fore wing; 47. hind wing; 48. hind leg; 49. hind claw; 50. apical antennal segments; 51. basal antennal segments; 52. hind tibial spurs and first tarsal segment; 53. head viewed from above; 54. head viewed from front; 55. propodeum.

Fore and *mid legs* orange-red, their coxae paler and femora darker than the tibia and tarsi; fore tibiae with one curved spur, their first tarsal segment notched near tibial spur. *Hind* coxae swollen and elongate, longer than broad (fig. 48), reddish-brown with small black patches proximally and distally; femur with blackish apex; tibia equal to femur and distal trochanter combined; first tarsal segment four-fifths the rest of tarsal segments combined; tibial spurs unequal (fig. 52); longer tibial spur nearly half and smaller tibial spur two-fifths the first tarsal segment; claw (fig. 49) with bristles basally.

Wings hyaline, brownish; pterostigma yellowish-brown, translucent; nervures blackish-brown; vein *r* longer than half $SR+R_3$; areolet pentagonal, as long as broad; M_3 intercepted very slightly below the middle; *r-m* slightly less than half M_2; M_2 curved in the middle; rest of the venation as in fig. 46. Hind wing four times as long as broad, infumate ; M_4-Cu_1 intercepted distinctly below the middle; frenular hooks 12; rest of venation as in fig. 47.

Abdomen depressed narrow towards apex; first abdominal segment depressed and flattened at its apex, narrow basally, longitudinally striated near base in middle, reddish-brown with blackish tinge in the basal half, its spiracles near the apex; rest of the abdominal segments strongly depressed, reddish-brown; the apical segment a little darker; second segment three-fourths the first, rugoso-punctate, punctae shallow and more or less uniform; rest of the segments indistinctly punctate and leathery in appearance; apex pubescent; *ovipositor* short, its sheath blackish at the apex.

Holotype female, on pin, No. 428/H, labelled, "School of Entomology Expedition to Himalayas, 1954; Narkanda: Ridge about two miles away on Hindustan-Tibet Road, 9500 ft; V. K. Gupta & M. Vishwanath Coll., 4-X-1954." Antenna, wings and hind leg of one side on slide of same number.

This seems to me the first record of this genus from India.

9. **Platylabus himalayana,** sp. nov.

Female.—Slender, medium sized species with head partly and thorax nearly black; abdomen dull reddish-brown. Length 10.5 mm, antenna about 8 mm, fore wing 8 mm, hind wing 5.5 mm and ovipositor 1.3 mm.

Head viewed from above (fig. 65) nearly transverse, slightly wider than thorax between tegulae; inter-orbital space less than half the width of head; vertex black, except near eyes; post-orbital space and front orbital margin deep yellow; occiput black; whole of vertex smooth and somewhat shiny; ocelli in the centre, brownish; inter-ocellar space a little less than ocellocular space. Viewed from front (fig. 64) broadly triangular, somewhat broader than long; frons between front ocellus and antennae depressed, smooth, black in the middle and yellow at the sides; face below antennae brownish in the middle and yellow at the sides. *Clypeus* imperfectly discrete from face, mostly brownish and yellowish at the edges, its apical margin straight. Genae smooth and yellow. Eyes large, nearly parallel sided internally and brown. Mandibles flavous basally and brownish-black apically; teeth unequal.

Antennae long, longer than head and thorax combined, inserted in the middle of face; scape small, oval and testaceous; pedicel and ring joint deep testaceous and short; flagellum with 36 segments, first flagellar segment (fig. 62) longer than second and two-third the second and third combined; basal seven segments deep brownish-black; segments 8-12 and part of 13th, pale-whitish; rest of the segments again brownish; apical segment acute and nearly double the preceding one (fig. 61).

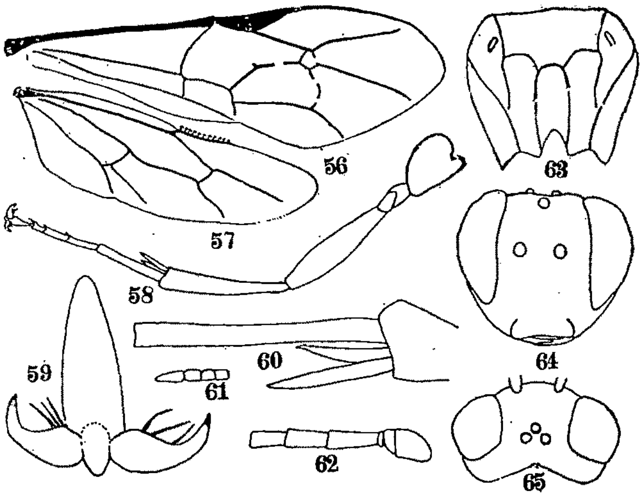

Fig. 56-65. *Platylabus himalayana,* sp. nov. Female.

56. fore wing; 57. hind wing; 58. hind leg; 59. hind claw; 60. hind tibial spurs and first tarsal segment; 61. terminal antennal segments; 62. basal antennal segments; 63. propodeum; 64. head viewed from front; 65. head viewed from above.

Thorax longer than high, compact, lightly covered with short pubescence; pronotum black, reddish-yellow near the mesonotum and testaceous near propleura; *mesonotum* slightly raised above the level of head, somewhat shiny and very shallowly and evenly punctate, black with two reddish-yellow stripes in the middle; parapsidal furrows absent; tegulae deep brownish; *scutellum* shiny, convex and separated from mesonotum by a deep groove, blackish in the middle and yellowish at the sides; anterior carinae of scutellum extending to near its apex; metanotum orange-red in the middle and depressed at the sides; mesopleurae black, shortly pubescent with an orange coloured stripe ventrally; metapleurae somewhat indistinctly rugose, black with an orange coloured spot in the middle. *Propodeum* black, except around the spiracles and near the apex where yellowish-brown patches are present; petiolar area distinct from the rest of propodeum by longitudinal carinae (Fig. 63); basal carina also present; basal area smooth and shiny; rest of propodeum coarsely punctate and somewhat pubescent; propodeal spiracles linear and elongate.

Legs reddish-testaceous, hind legs darker than the others. Fore and mid coxa and proximal trochanter yellowish, the former short; fore tibia with only one curved spur, their first tarsal segment notched near the curved tibial spur. Hind coxae somewhat elongate, deep reddish-brown and with black spots dorsally ;

proximal tarsi lighter; apex of tibia and femur blackish-brown; femur one and one-third the coxa and trochanters combined, nearly equal to tibia (Fig. 58); first tarsal segment nearly three-fifths the tibia and equal to second, third and fourth tarsal segments combined; tibial spurs sub-equal (fig. 60) larger tibial spur half and the smaller tibial spur two-fifths the first tarsal segment; claws (fig. 59) well developed, pointed, curved and with bristles basally.

Wings elongate, hyaline and infumate. Fore wing (fig. 56) with pterostigma light-brown; veins yellowish-brown; vein *r* issuing from near the middle of of pterostigma, straight, longer than half $SR+R_3$; areolet pentagonal, with its outer vein partly unpigmented, acute, but not petiolate; M_3 intercepted near the middle; M_4-Cu_1 emitted just beyond *M-Cu*; *r-m* less than half M_2; M_2 curved and unpigmented at places; rest of venation as in figure. Hind wing with 11 frenular hooks; M_4-Cu_1 intercepted below the middle; rest of venation as in fig. 57.

Holotype female, on pin No. 426/H, labelled, "School of Entomology Expedition to Himalayas, 1954; Narkanda: Ridge west of Rest House, 9500 ft., V. K. Gupta & J. P. Agarwal Coll., 3-X-1954." Wings and hind leg of one side on slide of same number.

This species differs from *P. vishwanathai* Gupta, in body colouration, shape and sculpture of head, face and propodeum; scutellum sub-convex; inter-ocellar space less than ocellocular space and other characters.

Tribe Eurylabini

10. **Eurylabus dholadharensis,** sp. nov.

Male.—Medium sized species with head and thorax black, face and scutellum yellow; abdomen reddish-brown in the middle, petiole and apical segments black; Legs yellowish-red. Length 15 mm, fore wing 12 mm and antennae 10 mm.

Head viewed from above (fig. 73) sub-quadrate, nearly twice as wide as long, inter-orbital space half the width of head; vertex closely trans-rugose, black; ocelli in the centre; ocellocular space five-sixths the inter-ocellar space; ocellar diameter half the inter-ocellar space; front ocellar space one-third, and post-ocellar space little more than the inter-ocellar space; vertex margined behind; post-orbital pubescent. Viewed from front (fig. 74) length three-fourths the width; frons between front ocellus and antennal sockets black, coarsely rugose and excavated; face below antennae yellow, shallowly and sparsely rugoso-punctate, sparsely pubescent, slightly elevated in the middle; genae black and densely pubescent; eyes large, bare and brownish; anterior orbital borders near the ocelli reddish-brown, rest yellow; post-orbital border black. *Clypeus* yellow, pubescent, a brownish-black line at the apex; indistinctly discrete at the base in the middle and broad at apex; anterior tentorial pits distinct and brownish-black.

Antennae inserted in the middle of face; black, longer than head and thorax combined; scape cylindrical, slightly longer than twice its width, yellowish anteriorly, rest black; pedicel and ring joint short; flagellum gradually narrowing towards the tip; first segment (fig. 72) nearly equal to the second; terminal segment (fig. 71) not longer than the preceding.

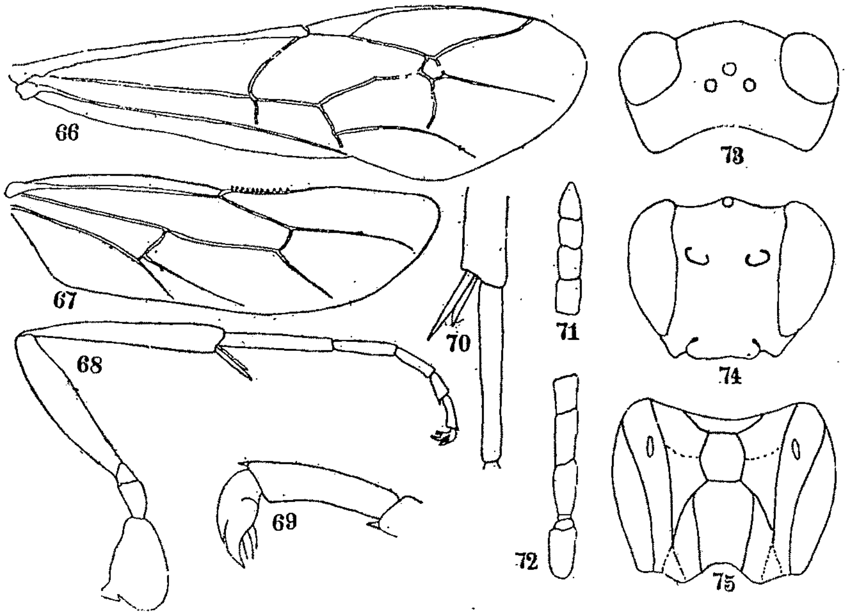

Fig. 66-75. *Eurylabus dholadharensis,* sp. nov. Male.

66. for wing; 67. hind wing; 68. hind leg; 69. hind claw; 70. hind tibial spurs and first tarsal segment; 71. terminal antennal segments; 72. basal antennal segments; 73. head viewed from above; 74. head viewed from front; 75. propodeum.

Thorax compact, slightly raised above the level of the head, nearly twice as long as high; pronotum with its lateral margins yellow; *mesonotum* black, coarsely rugoso-punctate, sparsely pubescent, without any parapsidal furrows; *scutellum* bright yellow, separated from the mesonotum by a deep depression, somewhat convex, covered with long dirty white pubescence; anterior carinae of scutellum reaching upto its base; tegulae orange-red; pro-and mesopleurae rugoso-striate, the latter somewhat rugoso-punctate anteriorly; metapleurae more rugoso-striate; covered with dirty-white long pubescence. *Propodeum* black, pubescent with a well developed areola (fig. 75); basal area rugose; areola and lateral area above costulae rugoso-sculptured, rest of propodeum rugoso-striate; propodeal spiracles elongate.

Fore and *mid legs* with coxae globose and yellow; trochanters and femur yellowish; tibia and tarsi light orange-red; fore leg with one tibial spur, which is slightly curved; first tarsal segment of fore leg slightly notched basally near the tibial spur; mid legs with two unequal tibial spurs. *Hind legs* (fig. 68) with coxae large and shallowly punctate, pubescent; proximal trochanter black, reddish yellow at the edges; distal trochanter and femur deep orange-red; a broad black patch on the inner side of apical one-third of femur; tibia yellowish in the basal half, orange-red distally, black in the apical one-sixth; tarsi orange-yellow; first tarsal segment half the tibia and nearly equal to second, third and fourth tarsal segments combined; last tarsal segment one and one-half the preceding segment; tibial spurs unequal (fig. 70), larger tibial spur three-sevenths and the smaller tibial spur about one-third the first tarsal segment; claw (fig. 69) well developed, curved at apex, with long stiff bristles near the base.

Wings long, brownish. Fore wing (fig. 66) with pterostigma pale straminous, nervures yellowish basally and a little darker apically; areolet large, pentagonal; *r-m* slightly shorter than R_5; length of areolet nearly equal to its width; vein *r* emitted from near the middle of stigma, more than half $SR+R_3$; *r-m* one-third M_2; M_3 intercepted below the middle; M_2 and M_{1+2} unpigmented at places. Hind wing (Fig. 67) with 11 frenular hooks; *r-m* unpigmented in apical half; M_1+Cu_1 intercepted below the middle, quite near the anal vein, very slightly geniculate; rest of the venation as in figure.

Abdomen depressed, slightly arched above. First abdominal segment black, its apical margin only reddish-brown, narrow at base but much flattened at the apex, two longitudinal carinae present near the base on either side of tergite but on the flattened apex they come on the middle of tergite and are more distinct on the apex; the distance between the carinae is equal to the width of the first abdominal segment at the base; rugose only apically and trans-striated laterally; its spiracles near the apex. Second abdominal segment slightly longer than the first. Second, third and fourth tergites gradually narrowing posteriorly, shallowly and minutely rugoso-punctate, reddish-brown; a black dot on the fourth tergite near its base in the middle; this black dot may be indistinct (paratype); rest of the apical segments mostly black, reddish-testaceous at sides; claspers dark reddish-brown.

Holotype male, on pin No. 429/H, labelled, "School of Entomology Expedition to Himalayas, 1954; Narkanda: Hindustan-Tibet Road, 9500 ft; V. K. Gupta Coll., 4-X-1954."

Paratype one male, on pin No. 427/H; wings, antenna and hind leg of one side on slide bearing same number; collected from the Holotype locality.

This is probably the first record of this genus from India.

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

PART XI.—ON FIVE NEW SPECIES OF COLLEMBOLA

By H. N. BAIJAL, M. Sc., *Government of India Research Scholar, School of Entomology, St. John's College, Agra.*

I take this opportunity of expressing my grateful thanks to Prof. Dr. M. S. Mani for facilities for work, constructive criticism and encouragement. Valuable advice from Dr. J. T. Salmon of the Victoria University College, Wellington, New Zealand is also gratefully acknowledged.

The type specimens are being deposited in the collections of the Zoological Survey of India, Calcutta.

Suborder ARTHROPLEONA
Superfamily Poduroidea
Family Hypogastruridae
Subfamily Hypogastrurinae

Achorutes narkandae, sp. nov.

Brownish, generally mottled. Ocellar field black. *Clothing* sparsely clothed with long simple setae somewhat numerous around posterior portion of abdomen. Cuticle very strongly tuberculate and granulate. *Body* (fig. 1) Length 2.5 to 3 mm. Antennae (fig. 3) a little longer than head. Ant. segments I : II: III : IV as 10 : 8 : 12 : 10. Antennal segment IV apically with a single sense rod and knob. On the side of antennal segment III a sac-like structure. Ocelli (fig. 4) 8 on each side, equal and on black fields. Postantennal organ with 4 peripheral lobes. Two strong, long and distinctly curved anal spines (fig. 5). Each spine little longer than hind claw and mounted on a large papilla. The two papillae not touching basally. *Legs* (fig. 2) similar and stout; unguis with inner teeth somewhat beyond the middle. No outer teeth. Unguiculus needle-like reaching to tooth of claw and with a broad inner lamella for about half its length. A single non clavate tenent hair to each foot. *Furcula* short (fig. 6), the dens two and a half time as long as mucro, which is rounded apically with broad inner lamella. Dens with four long setae.

Cotypes on slide, several in spirit, feeding on mushrooms, on Simla-Tibet Road between 154-158 miles, Narkanda near Sutlej Valley, 9500 ft. Coll. M. S. Mani & H. N. Baijal, 4-X-1954.

This species is near to *Achorutes armatus* Nicolet[1] from which it can readily be distinguished by the total absence of serated setae, absence of large-sac-like

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*Contribution No. 64 from the School of Entomology, Agra; published with the permission of the Professor of Zoology & Entomology.

[1] SALMON, J. T. 1941. *Trans. Roy. Soc. N. Z.*, 290-291, pl. XIi, fig. 35-38.

organ between segment III and IV. Antennal segment IV without seven thick sensory hairs around the apex and lastly absence of lateral outer teeth from legs.

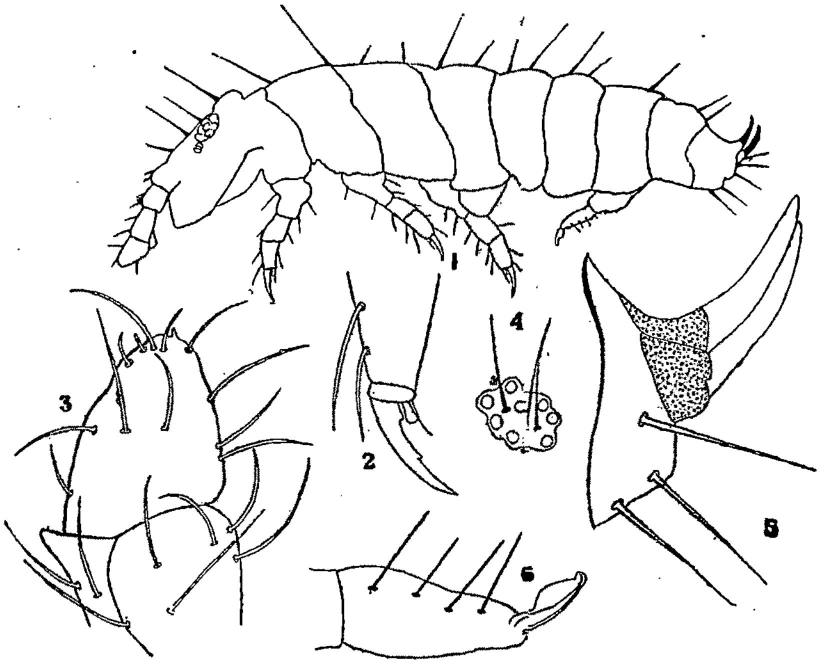


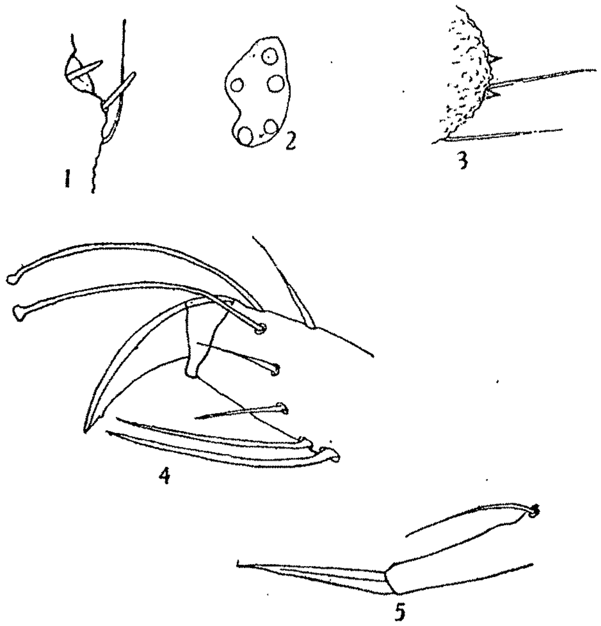
Fig. 1. *Achorutes narkandae*, sp. nov.
Fig. 2. Unguis and unguiculus of hind leg.
Fig. 3. Apex of the antennae.
Fig. 4. Ocelli of right side.
Fig. 5. Anal spines.
Fig. 6. Mucro and apical portion of dens.

Xenylla hadialii, sp. nov.

Black. *Clothing* No setae dorsally except on abdominal segments V & VI, sparsely clothed laterally and posteriorly with short, plain setae. Cuticle tuberculate. *Body* length 2-2.5 mm. Ocelli (fig. 2) five to each side and equal. Postantennal organ absent. Antennae four segmented, as long as head. Segments III & IV indistinctly separated. Antennal segment I:II:III+IV as 6:8:22. Antennal segment III (Fig. 1) with a pair of elongated sense rod and Antennal segment IV apically with a pair of sense knob. Anal spines (fig. 3) minute and on papillae. *Legs* (fig. 4) with a single tooth at three-fourth of unguis. Unguiculus absent. Two well developed, long and curved clavate tenent hair to each tibio-tarsus. *Furcula* (fig. 5) small, not reaching to ventral tube, mucro elongate and tapering. Dens with a single long setae.

Cotypes partly dissected on slide; two on slide, one in spirit. Ex. Mosses; Narkanda west side from Dak Bunglow, 9500 ft., Simla —Tibet Road, near Sutlej Valley; Coll. Hadi Ali & H. N. Baijal, 3-x-1954.

This species is near to *Xenylla obscura* Imms[2] but differs in having two long well developed tenent hair, nature of anal spine and lastly by the presence of teeth in claw.



Xenylla hadialii, sp. nov.

Fig. 1. Right side of third antenal segment with sense rods.
Fig. 2. Ocelli of right side.
Fig. 3. Anal spines.
Fig. 4. Unguis and unguiculus of hind leg.
Fig. 5. Mucro and apical portion of dens.

Superfamily MYDONIOIDEA
Family Mydoniidae
Subfamily Mydoniinae
Tribe Mydoniini
Mydonius manni, sp. nov.

Black with irregular white spots on the body and leg as follows, the whole body is black with white spots and irregular scattered streaks on the body but with broad ochreous on the first thoracic segment. The head laterally with black markings, dorsally ochreous. Antennal segments I black, II, III and IV brown. Legs black with whitish band at the joints and apical portion. Furcula grey with triangular yellow marks at the base of manubrium. Apical portion of dens and mucro yellow. Ocellar field black. *Clothing* Head, thorax and abdominal segments I-III dorsally and thoracic segments I, II and III laterally with many long flexed setae. Antennae, legs and furcula heavily clothed with ciliated setae, some of which are very long. *Body* Length 3.5-4 mm. Antennae three times as

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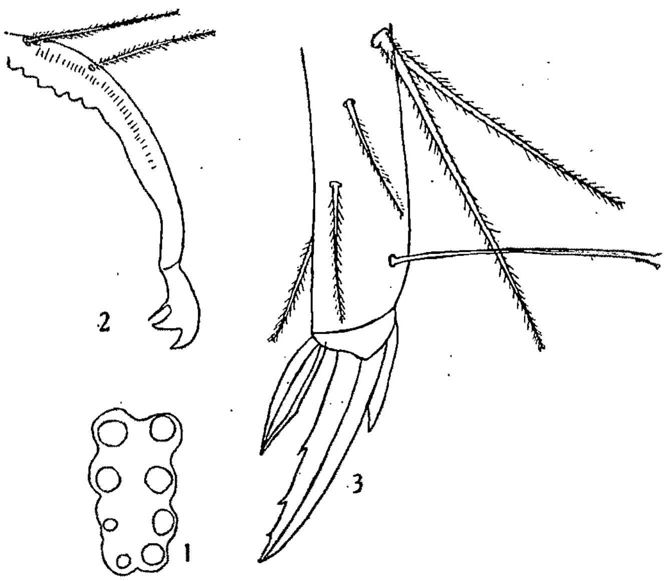
IMMS, A. D., 1912. *Proc. Zool. Soc. London,* 84-85, pl, vi, fig. 5-9.

long as head, the four segments related to each other as 50: 90: 90 : 92. 8 ocelli to each side (fig. 1) with anterior pair very large, four medium and two small. The posterior smaller ocellus is very near the posterior larger ocellus. Abdominal segment IV six times as long as III. *Legs* (fig. 13) Unguis with a pair of long outer lateral basal teeth, a pair of inner teeth in the middle and a distal teeth at three quaters and smaller distal tooth at seventh-eighths down. Unguiculus lanceolate reaching little more than centre of unguis. A single clavate tenent hair just equal to unguis to each foot. *Furcula* (fig. 12). Mucro dens, little longer than manubrium, the unannulated portion three times as long as mucro and passing towards the mucronal spines. Mucro distinctly separated from dens, bidentate with basal spine, the two teeth subequal the spine equal to basal teeth. Dens with ciliated setae.



Mydonius manii, sp. nov.

Fig. 1. Ocelli of right side.
Fig. 2. Mucro and apical portion of dens.
Fig. 3. Unguis and unguiculus of hind leg.

Cotypes on slide, several on slide and in spirit, feeding on Mushrooms, Narkanda, coll. M. S. Mani, 3-X-1954.

This species is near to *Mydonius exfoliata* Salmon[3] from which it can readily be separated by the character of furcula and antenna.

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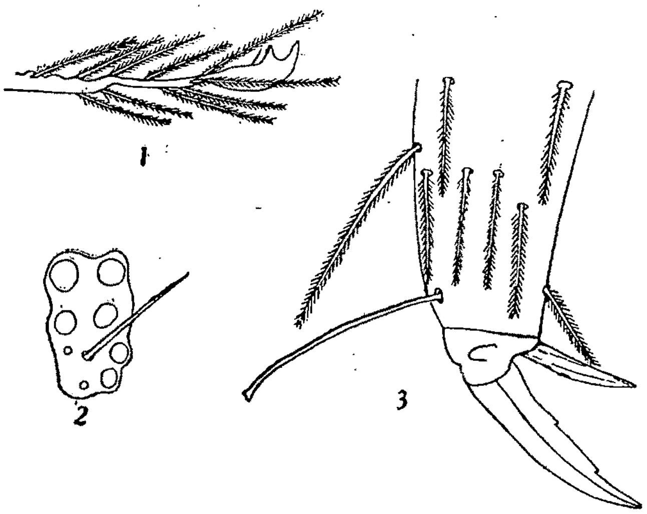
[3] SALMON, J. T. 1943. *Trans. Roy. Soc. N. Z.* 385-386, pl. XLII fig. 52-55.

Pseudentomobrya indica, sp. nov.

White to Yellowish with black ocellar field and dark band joining these and the antennal bases. A generally continuous (but somewhat broken) lateral longitudinal stripe across all segments. A similar lateral stripe just above the previous runs from first thoracic to third abdominal segment. The posterior margin of III abdominal segment has a black stripe and IV abdominal segment with large lateral irregular black spots. The entire V abdominal segment is black. The first two legs and furca white to yellowish. The third pair of leg and antennal segment III, IV black. *Clothing* clothed with both plain and ciliated setae and those around the posterior being long. A tuft of flexed setae at the margin of mesothorax and last abdominal segment. *Body* upto 3-3.5 mm, antennae two and a half times longer than head, the four segment related as 6: 11: 11: 14. Ocelli (fig. 2) 8 to each side with anterior pair very large, four medium and the two small. Abdominal segment IV six times longer than abdominal segment III. *Legs* (fig. 3). Unguis with teeth near the centre and a tooth just past three-quarter. No outer teeth. Ungiuculus lanceolate two-thirds as long as unguis. A single clavate tenent hair about as long as claw to each foot. *Furcula* (Fig. 1). Dens strongly annulated and corrugated, the non annulated portion one and a half times than mucro. Mucro elongate and bidentate with basal spine equal to subapical tooth which is equal to apical tooth. Mucro surrounded by delicate ciliated setae.



Pseudentomobrya indica, sp. nov.

Fig. 1. Mucro and apical portion of dens.
Fig. 2. Ocelli of right side.
Fig. 3. Unguis and unguiculus of hind leg.

Cotypes on slide, several in spirit, ex. mosses on Simla-Tibet Road, between 154-158 miles Narkanda, near Sutlej Valley, 9500 ft, Coll. H.N. Baijal, 4-X-1954.

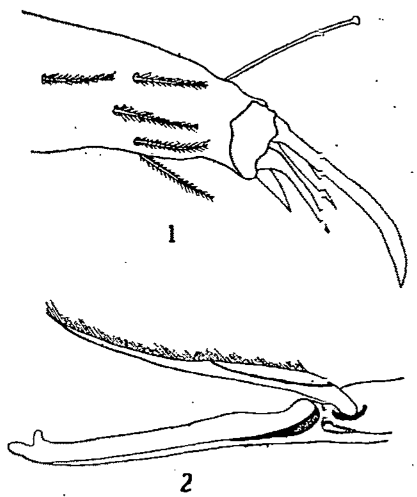
This species is near to *Pseudentomobrya glaciata* Salmon[4] from which it differs in general body markings and in the character of mucro.

Subfamily Cyphoderinae

Tribe Cyphoderini

Cyphoderus rubiae, sp. nov.

Creamy-white. *Clothing* clothed with short simple and ciliated setae on antennae, ventrally on body and on legs, somewhat longer straighter, plain and ciliated setae. *Body* length 2-2.5 mm. Antennae longer than head. Antennal segment I: II: III : IV related as 10: 25 : 15 : 31. Antennal IV annulated. Ocelli and post antennal organ completely absent. Abdominal segment IV five times that of abdominal segment III. *Legs* (Fig. 1) all similar. Unguis with a single large basal inner tooth, no outer teeth. Unguiculus unarmed and lanceolate with a single pointed and leaf like lamellae. A single clavate tenent hair shorter than claw to each tibiotarsus. *Furcula* (Fig. 2) Mucro long, slender, and straight, bidentate and the two teeth subequal. The manubrium and dens clothed ventrally with scales, the dens provided with a single row of plumed scales on dorsal side and the dorso-apical scale is large and subequal to mucro.



Cyphoderus rubiae, sp. nov.

Fig. 1. Unguis and unguiculus of hind leg.
Fig. 2. Mucro and apical portion of dens.

Cotypes on slide, one in spirit, under stones, Tibet Road between 154-158 miles, Narkanda, Coll. H. N. Baijal, 5-X-1954.

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[4] SALMON, J. T. 1941. *Trans. Roy, Soc. N. Z.*, 367, pl. lxi fig. 346-348.

This species is near to *Cyphoderus assimilis* (*simulans*) Imms[5] described from Khayan caves near Moulmein, Burma and by Handschin[6] from Kuteri valley, Nilgiris (India) but differs in the absence of inner teeth from claw and presence of single row of plumed scales on dens and from its unguis which is unarmed.

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[5] Imms, A. D. 1912. *Proc. Zool. Soc. London*, 115-116, pl. xii, fig. 90-91.

[6] Handschin, 1929. *Rev. suisse. Zool.* 36 p. 259.

CYTOPLASMIC INCLUSIONS IN OOGENESIS IN TWO MAMMALS

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SUMMARY

This paper deals with a brief account of the cytoplasmic inclusions during oogenesis in *Capra aegagrua* and *Ovis vignei*, the general anatomical and cytological features of the ovaries of both of which conform to the usual mammalian type. The central and peripheral follicular cells give rise to the cytoplasmic sheet and albuminous globules respectively, the latter being derived also from the theca cells. As the development proceeds the oocytes exhibit changes from uninuclear to the polynuclear and back to the uninuclear stage. The Golgi elements occur in the form of dictyosomes and platelets only. Although there is no true reticulation, the close aggregation of the Golgi elements presents a pseudo-reticulated appearance. The mitochondria are granular and are derived purely from non-granular cytoplasmic source. The extruded nucleolar particles apparently look like yolk nucleus of Balbiani. The extruded particles grow in size in the cytoplasm. The fatty yolk is derived from the Golgi elements, while the mitochondria give rise to albuminous yolk. The vacuome differs in topography, size and shape.

Although considerable amount of work has been in progress (vide references) on the cytoplasmic changes in the oogenesis of various mammals, our knowledge of the subject is still largely fragmentary. A number of common species still remain uninvestigated. Recently Prasad (31-35) has described the behaviour of mitochondria and certain aspects of the golgi apparatus in the Indian cattle, the water-buffalo and *Ovis*. He has also discussed the role of vitamin C in the oogenesis of the last mentioned species. This paper deals with a brief account of an investigation, completed several years ago, on the cytoplasmic inclusions during oogenesis in *Ovis vignei* and *Capra aegagrus*.

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MATERIAL AND METHODS

The material for the investigation was obtained from the Agra Slaughter House. Pieces of the tissue removed from the animal immediately it died, were cut in normal saline and transferred to various well known fixatives, like Aoyama, DaFano's cobalt-nitrate modification, Cajal, etc. Mann-Kopsch osmic fixative of Ludford was also used. Imbedding and sectioning in the usual way was followed by the standard staining technique. The general anatomy and cytology of the ovary of the two animals studied conform to the usual mammalian type.

Capra aegagrus

The General Structure of the Ovary.—During the course of the development the oocytes exhibit a remarkable series of changes from the uninuclear to the polynuclear and back to the uninuclear stage (Pl. XX, Figs. 1,2 and 3). The central mass of cells of the follicle persistently undergoes degeneration (Pl. XX, Figs. 5, 9 and 12), whereas the external follicle cells, on degeneration, exhibit various stages in the formation and arrangement of the albuminous globules and vacuoles (Pl. XVII, Figs. 1,2 and 3; Pl. XVIII, Figs. 5,6 and 7; Pl. XIX, Figs, 1,23,4and 5).

Golgi bodies in oocyte and follicular epithelium.—Owing to the typical compactness of the material, it has been found difficult to study the oogonial stages. A few Ludford and silver preparations however show the Golgi elements even in the oogonia. In the very early oocytes, the Golgi elements first make their appearance as fine granular structures, massed together in a juxta-nuclear position (Pl. XVII, Fig. 6). This area disintegrates in the subsequent stages and a perinuclear layer of the Golgi substance is established (Pl. XVII, Fig. 7). In a lightly larger oocyte, a fair sprinkling of the Golgi elements into the cytoplasmic area occurs (Pl. XVII, Fig. 5). Some of them may be seen almost in close vicinity of the limiting membrane (Pl.XVII, Fig. 5). Their transmission continues towards the periphery and at a still later stage, in bigger oocyte, the Golgi elements arrange themselves at the periphery to form the perpheral ring so commonly met with in vertebrates (Pl. XVII, Fig. 4). The medullary region is practically free from the Golgi bodies which become confined to the periphery.

The infiltration of Golgi bodies.—In a more advanced oocyte with fully developed zona radiata, the cortical layer is fairly broad and contains the bulk of the Golgi substance of the oocyte. In the same oocyte the Golgi elements from the follicular cells begin to exude into the oöplasm through the zona radiata (Pl. XVII, Fig. 8).The radial striations or the well-known channel-like passages in the zona radiata were not observed in the material examined by the present author. Such an infiltration is not localised to a particular portion of the zona radiata, but is effected throughout its length. The Golgi elements after infiltration, which is always haphazard, come to lie in the ooplasm, where too they do not undergo any methodical spreading. Further the Golgi elements of the follicular epithelium and those of the oocyte proper show no remarkable diversity from the morphological point of view. The early oocytes exhibit a close network of the Golgi elements due probably to vesicles and crescents massed together. In advanced oocytes the Golgi elements are in the form of granules, platelets and dictyosomes. The individual platelets or dictyosomes are composed of an osmiophobic and argentophobic centre surrounded by an osmiophil and argentophil rim. This structural peculiarity is, however, better studied in suitable osmic preparations than in silver as it effects the homogeneous impregnation of the entire body. In osmic preparations too this difficulty becomes insurmountable if the material is over-impregnated.

Mitochondria.—The difficulty of fixing the early oocytes has invariably been confronted in view of the compactness of the material which hardly permits free penetration of the various fixatives. It was, therefore, by no means very easy to distinguish the mitochondria of the undifferentiated germ-cells. However, successful preparations of Flemming without acetic acid and Regaud-Tupa stained with acid fuchsin and iron-alum haematoxylin were advantageously used for the study of the mitochondria. Champy preparations stained with iron-haematoxylin gave an equally convincing picture.

In the very early oocytes, the mitochondrial patch is in the form of a mass closely applied to the nuclear membrane (Pl. XVIII, Fig. 1). Later, in somewhat advanced oocytes, the juxta-nuclear mass of the preceding stage becomes still more prominent and covers almost half the nuclear membrane (Pl. XVIII, Fig. 2). At a still later stage, the mitochondria tend to spread all along the nuclear periphery and soon a perinuclear ring is established (Pl. XVIII, Fig. 4). In the subsequent stage this condition is soon lost and the mitochondrial ring now tends to move outwards to the medullary region of the egg. As the mitochondria begin to break away from the nuclear membrane and disperse all over the cytoplasm, they form prominent scattered patches in it. The remnants of the juxta-nuclear mass may, however, persist for sometime (Pl. XVIII, Fig. 3). At the stage when the Golgi ring had left its perinuclear condition and made its way towards the cortex the mitochondria were observed to be finally dispersed int he cytoplasm. The younger eggs being not well fixed, the exact method of dispersal could not be traced. Either directly from the juxta-nuclear position or through an intermediate stage of perinuclear condition the mitochondrial concentration disintegrates, allowing a fair dispersal of its elements all over the cytoplasm. Finally, these fine structures head towards the cortex and soon a peripheral layer, immediately beneath the zona pellucida, is established.

All the mitochondria, which could be well fixed in chrome-osmium and chrome-formol preparations, were exceedingly granular in shape. As they grew in size, they became globular so that any differentiation between small albuminous yolk bodies and swollen mitochondria became difficult. A few rodlet-like bodies were sometimes observed. They are highly fuchsinophil dust-like particles of irregular shape. Other forms (filamentous, rod-shaped, clump-shaped and others) described by workers on various animals were not observed.

The Nucleus and the Nucleolar Extrusions.—Inspite of the unsuitability of the material the nucleolar extrusions were very well fixed and studied in the Bouin slides stained with Mann's methyl-blue eosin. Indications of the presence of such a phenomenon were not wanting in Regaud-Tupa and Flemming without acetic acid.

In the earliest available oocytes the nucleus contains traces of chromatin material in the form of a loose reticulum of faintly staining threads, in the meshes of which has been observed a single rather brilliantly coloured basophil nucleolus (Pl. XX, Fig. 4). A big nucleolus is very characteristic in the eggs of this animal. This basophil nucleolus in the subsequent stages embarks on a particular phase of dividing rapidly and thus liberates, as shown in (Pl.XX,Fig.5), a few small spherical plasmosomal bodies which strictly keep confined to the cytoplasmic area of the nucleus. One of these plasmosomal bodies extruded from the nuclear cytoplasm is also shown in the same figure. These bodies arise spontaneously out of the nucleoplasm. At a particular stage of development the capacity of fission on the part of the plasmosome increases many folds and consequently a greater number of plasmosomal buds are thrown out which arrange themselves on the peripheral portion of the nucleus and also to some extent inside the nucleus. Some of these extruded bodies migrate to the periphery of the occyte and form a large conspicuous mass as in fig. 6, Pl. XX. The nucleus of such an oocyte shows a marked chromatin in the form of a network. From this stage the nucleoli, formed by the budding of the original nucleolus, seem to migrate into the cytoplasm. A single extruded plasmosomal body, in a younger oocyte, is found to pass through the nuclear membrane and lodge itself in the cytoplasm in the immediate vicinity of the nucleus (Pl. XX, Fig. 7). In the next stage is seen the act of passing out of the plasmosomal body through the nuclear membrane. It is half inside the nucleus and half outside it (Pl. XX, Fig. 8). The constitution of the nuclear membrane is such that it readily permits the extrusion of these bodies. The following stage represents an early oocyte in which two nucleoli have been extruded, both lying close to the nuclear membrane (Pl. XX, Fig. 9). After sometime the extruded plasmosomal bodies, in a comparatively bigger oocyte, move away from the vicinity of the nucleus and are found midway, that is, between the nuclear membrane and the extreme periphery of the egg (Pl. XX, Fig. 10). Later on the presence of the extruded nucleolus in the cortical region has been observed (Pl. XX, Fig. 11). As this movement continues, in an early oocyte, two extruded plasmosomal bodies are seen almost clinging to the extreme periphery of the egg (Pl. XX, Fig. 12). Finally a stage has been observed, as represented in (Pl. XX, Fig. 13), when three such extruded plasmosomal bodies are brought to view embracing the extreme periphery of the egg. Here the conspicuous plasmosomal bodies either disintegrate into its finer elements or completely dissolve out. Their ultimate fate, however, could not be traced. In sufficiently advanced oocytes no trace of these bodies was detected.

A considerable increase in the size of the plasmosomes begins to be clearly demonstrable with the gradual migration of the plasmosome towards the periphery (Pl. XX, Figs. 12 and 13). Such large-sized plasmosomes are, however, never extruded as such from the nucleus. The plasmosome continues to grow in the ooplasm. The plasmosome near the periphery undergoes a further differentiation into an inner clearer vesicle and an outer denser cortex. The inner vesicle contains a few isolated granules which are rather deeply stained, but the outer cortex is itself densely stained (Pl. XX, Fig. 13). Gradually the plasmosome grows smaller and smaller in size and the central clearer vesicle disappears totally. Soon after, the denser cortex shrinks, becomes fainter and ultimately disappears.

Yolk bodies. The formation of yolk bodies could not be demonstrated in a remarkably lucid manner in Bouin and silver preparations as they are entirely fatty in nature. An equally convincing picture was seen in Ludford's modification of Mann-Kopsch's technique, which was a step further to confirm the observations available in silver fixatives. Regarding proteid yolk formation, the author finds that no such bodies are present, either in the fixed preparations or the living cells, in the eggs of this animal. The osmic slides were also given a prolonged treatment in turpentine to ascertain the absence of deutoplasmic spherules in the normal and healthy oocytes of this animal.

Centrifuge Experiments. Small pieces of the ovaries of goat varying from an early to an advanced stage, were centrifuged at a velocity of 3,500 revolutions per minute, for one to four hours. The material thus treated was fixed in Champy-Nassonov, Da Fano and Ludford fixatives. They were bleached and stained by Champy-Kull method. Both stained and unstained preparations were examined without any significant results.

Supra-vital Staining Experiments.—Since the ovary presents a rather compact mass with very extensive co-existent connective tissue, the technique of vital staining has proved only partially satisfactory. Stock solutions of neutral red and Janus green B, .1 gm. of either stain in 50 c.c. of salt solution (6 gms. in 1000 c.c. of distilled water), were left in the bath for about 12 hours. The material teased in salt solution was kept in a trough containing dilute solution of neutral red just pink in colour, and finally examined in the same solution under an oil immersion lens.

In about 40-50 minutes a number of globules, ranging from minute dust to conspicuous large-sized particles, stained cherry red were observed. In the very early oocytes the vacuome was concentrated in a juxta-nuclear area only (Pl. XXI, Fig. 1). Inside this region unstained refringent granules—Golgi bodies were also observed lying in association with the vacuome or in its close proximity. The neutral red granules—the vacuome and the Golgi bodies thus occur simultaneously. They are similar in size and shape. Crescent-shaped refringent granules recorded by other workers have not been detected in the eggs of this animal.

That the refringent granules are really Golgi bodies is confirmed by running in a drop of osmic acid under the cover-slip of a supra-vital preparation, when the Golgi bodies turn black while the neutral red vacuome remains unaffected. In two supra-vital preparations treated by osmic acid and at different stages of the oocytes, a gradual change in the distribution of the vacuome and the Golgi bodies with regard to the nucleus is clearly seen. In the early oocyte (Pl, XXI, Fig. 2) the vacuome and the Golgi bodies still continue to remain juxtanuclear or nearly so, as in the very early oocyte shown in Fig. 1, Pl. XXI. As development proceeds these two elements gradually become scattered throughout the cytoplasm and thus lose their juxta-nuclear orientation. (Pl. XXI, Fig. 3). At a still later stage depicted in Fig. 4, Pl. XXI, they have arranged themselves close to the periphery of the oocyte.

For mitochondrial demonstration, supra-vital staining with Janus green B, prepared as indicated above was employed. In an early oocyte treated in this way the juxta-nuclear orientation of the mitochondrial particles is clearly shown in Fig. 5, Pl. XXI. At a later stage the mitochnondrial elements become more or less uniformly scattered in the cytoplasm. Some of these particles tend to accum ulate into mitochondrial patches (Pl. XXI, Fig. 6).

Tests for detecting Fat. Treatment with Sudan III and Sudan IV as well as Scharlach R. of fresh and material preserved in formalin failed to give any indication of the presence of fat.

Ovis vignei

The General Structure of the Ovary.—The undeveloped oocytes become differentiated from the general epithelium to lie somewhat deep within the stroma. In the early stages the oocytes lack follicle cells, but as development proceeds some of the epithelial cells form the first layer of follicle cells round the early oocyte. Simultaneously the oocytes gradually increase in size and also move downwards towards the interior of the ovary. The single-layered follicle cells undergo division and give rise to a multi-layered follicle as in Fig. 1, Pl. XXII.

The various stages of the formation of the albuminous globules and the vacuoles, with progressive migration of the vacuoles to the periphery, and the uniform distribution of the albuminous globules followed pretty closely the same course as described in goat (Pl. XXII, Figs. 5, 6 and 7; Pl XXIII, Figs. 1, 2 and 3). The increase in the vacuoles progresses so far that ultimately the cytoplasm becomes reticulated with vacuoles and the albuminous globules become granular and sparse. (Pl. XXIV, Figs. 1-6).

That the formation of the albuminous globules may not entirely be attributed to peripheral follicle cells, but to a certain extent theca cells also, is made abundantly clear in Fig. 10, Pl. XXV. This, however, establishes the fact that some of the theca cells are also consumed in the process.

The disposition of the Golgi bodies in the oocyte and the follicular epithelium. In the sheep the Golgi bodies are readily demonstrated in Ludford and silver preparations. At first, the Golgi bodies are finely granular and juxta-nuclear in position (Pl. XXII, Fig. 2). When the Golgi bodies have thus become differentiated, the oocytes have not yet become enveloped by follicle cells. Very soon the juxtanuclear Golgi elements gradually increase and spread practically all round the nucleus, until they are completely perinuclear (Pl. XXII, Fig. 3). A little later (Pl. XXII, Fig. 4) the Golgi elements spread out in the cytoplasm and reach even upto the periphery. The bulk of the granules, however, still retain their perinuclear position. At this stage the follicular epithelial cells increase and give rise to several layers. The Golgi elements break off from the perinuclear zone, migrate gradually radially outwards and ultimately in a large-sized oocyte they become concentrated in an irregular patch immediately beneath the zona pellucida. Very often in the place of irregular patches, the Golgi granules lie evenly just in the cortex all round the oocyte.

Although in the early oocytes due to minuteness of size, it is not possible to satisfactorily study the Golgi form, yet it is often possible to observe them in the form of platelets and dictyosomes.

The infiltration of Golgi bodies from the follicular epithelium to the egg. In a somewhat advanced oocyte with the Graafian follicle containing two or three layers of follicle cells, the Golgi elements of the latter exhibit the incidence of infiltration through the zona pellucida into the oocyte (Pl. XXIII, Fig. 4). Atnostage of the Golgi infiltration could be detected the existence of any special striations or channels for their passage and also the infiltration itself does not appear to be governed by regularity with regard to the place where it is initiated. It is in fact a haphazard process.

Mitochondria.—Mitochondria were easily studied in material treated with Flemming without acetic acid, Regaud-Tupa stained in iron-alum-haematoxylin and acid fuchsin and aurantia. Champy preparations stained with iron-haematoxylin were also satisfactory.

At their first appearance, the mitochondria are juxta-nuclear in position (Pl. XXIII, Fig. 5). In an advanced oocyte (Pl. XXII, Fig. 7) this juxta-nuclear crescentic mass of fine granules becomes bigger and denser. Later on, the mitochondria spread out and thus establish a partial perinuclear ring. At the same time the follicular epithelium also appears (Pl. XXIII, Fig. 6). Ultimately, a perinuclear layer is established (Pl. XXIII, Fig. 8). When the mitochondrial elements are breaking off from their perinuclear situation, the mitochondria have already become, more or less, uniformly dispersed in the cytoplasm. At the next stage, the mitochondria become peripherally arranged immediately beneath the zona radiata.

The mitochondria are exceedingly granular and difficult to study in the undifferentiated germ cells. Some are also rodlet-shaped and others are fuchsinophil dust-like particles of irregular shapes.

The Nucleus, Nucleolus and Nucleolar extrusions. In the very early oocytes the nucleus is centrally placed and is easily recognised (Pl. XXV, Figs. 6 and 7), but sometimes the nucleus is not exactly central (Pl. XXV, Fig. 7). It generally occupies the bulk of the space of the oocyte, the cytoplasm being very meagre. In these single-layered oocytes, no traces of follicular epithelium have been observed.

In a somewhat older oocyte the cytoplasm begins to increase in quantity and the nucleus comes to occupy a smaller area (Pl. XXV, Fig. 8). The nuclear membrane appears smooth and regular.

As the oocyte grows older, two oocytes sometimes appear to lie close together (Pl. XXV, Fig. 2). In the same figure it is significant enough to note that the closely applied nuclei are bounded together by a common membrane. This is the binuclear stage of the oocyte, preceding the poly-nuclear condition represented in Fig. 3, Pl. XXV. Ultimately, once again by process of disruption, the uninuclear condition is restored (Pl. XXV, Fig. 5). The vestigial forms of the extranuclei are still noticeable in the same figure.

The chromatin material is finally perceptible in an early oocyte. The nucleolus is conspicuously large and is basophil. In due course the nucleolus passes through a somewhat complicated process of division in which the following definite stages may clearly be marked.

At first in an early oocyte we find a single nucleolus, usully central in position, within the nucleus (Pl. XXV, Figs. 1 and 4). Gradually the nucleolus becomes slightly excentric (Pl. XXV, Fig. 6). A very pronounced and well-marked nucleolus has been observed in the oocytes of this animal. Fig. 7, Pl. XXV represents young oocytes in the middle one of which two nucleoli—one of them lying deep within the nucleus and the other just touching the nuclear membrane—are seen lying inside the nucleus. During the earlier stages of the growth period nothing remarkable happens, but soon afterwards in more advanced oocytes, plasmosomal bodies push out through the nuclear membrane (Pl. XXV, Fig. 8). In the figure the extruding nucleolus is represented just almost half outside the nucleus, it is actually in the act of extrusion. Alongside the extruding nucleus (Pl. XXV, Fig. 8) has been observed a rather conspicuous plasmosomal body lying close beneath the periphery of the oocyte and the zona radiata. A little later, as this movement continues, two extruded plasmosomal bodies are found lodged in the cytoplasm between the nuclear membrane and the membrane of the oocyte (Pl. XXV, Fig. 9). They are here quite prominent as globose bodies.

No difference exists between the shape, size and the reciprocacity towards staining reactions, on the part of the plasmosomes found just on the inner side of the nuclear membrane and those either in the act of extrusion or otherwise. As mentioned above, it has often been observed that the plasmosomes pass bodily out of the nucleus.

As has already been described for goat, the extruded plasmosomal bodies gradually migrate towards the periphery of the oocyte. As this migration progresses there is a gradual swelling of the individual plasmosomal bodies in the cytoplasm. After these bodies have reached the periphery, differentiation into a denser cortex and a clearer inner vesicle described in goat has not been observed in sheep. Ultimately, the extruded nucleolar bodies are dissolved in the cytoplasm.

Yolk bodies. The fatty nature of the yolk bodies prevented their successful depiction in both the fixed preparations and the living cells. There was no definite indication of these bodies in the material fixed in Ludford's modification of Mann-Kopsch, silver fixatives and Schriddes method.

Centrifuge Experiments. Although small pieces of the ovaries of sheep of different ages were centrifuged at about 3,500 revolutions per minute for about four hours, no definite results could be observed with reference to the various cytoplasmic inclusions.

Supra-vital Experiments. The vital staining experiments described in detail under goat were carried out with the sheep ovary also. In about an hour a number of globules begin to make their appearance within the oocytes. The globules vary very much in size and are deeply stained cherry red. In the early oocyte, as usual, the vacuome is concentrated and is closely applied to the nucleus (Pl. XXV, Fig. 1). Within the same region certain unstained refringent granules represent Golgi bodies, and they lie in association with the vacuome. Both the Golgi bodies and the neutral red-stained vacuome are vesicular in type. The vacuome and the Golgi elements scatter as already indicated, more or less, uniformly in the cytoplasm (Pl. XXVI, Fig. 2).

Supra-vital staining for demonstration of mitochondria was also successfully carried out as described in goat. The early stage oocyte with the mitochondria in the juxta-nuclear position has not been observed. In the earliest stage studied, the mitochondrial granules are uniformly scattered in the oocyte (Pl. XXVI, Fig. 3). An important difference between the sheep and goat may here be noticed. In the case of the goat some of the mitochondrial particles howed a tendency to gather together in mitochondrial patches (Pl. XXI, Fig.6); in the sheep, however, the mitochondria do not appear to share this tendency of aggregation. In fact no mitochondrial patches have been observed (Pl. XXVI. Fig. 3). Later on, the mitochondria gradually appear to migrate towards the periphery to form irregular mitochondrial patches at the periphery (Pl. XXVI, Fig. 4). A similar sub-peripheral orientation of mitochondria is also readily observed in fixed material.

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KEY TO THE REFERENCE LETTERS USED IN FIGURES

Gep.	Germinal epithelium.
Pf.	Primary oocytes.
Atr.	Atretic follicle and ovum.
F.	Small Graafian follicle.
Gf.	Large Graafian follicle.
Fib. Cell. Str.	Fibro-cellular stroma.
F.E.	Follicular epithelium.
Th. Fl.	Theca folliculi.
Mem. Gr.	Membrana granulosa.
Disc. Prol.	Discus proligerus.
Z.P.	Zona pellucida.
N.	Nucleus.
Nu.	Nucleolus.
V.	Vacuole.
F.B.	Fat body or droplet.
Chr.	Chromatin.
Cr. Sp.	Crescentic spaces.
G.B.	Golgi bodies.
Inf. G.	Infiltration of Golgi bodies.
M.	Mitochondria.
M.P.	Mitochondrial patch.
Nu. Ex.	Nucleolar extrusion.
Vac.	Vacuome.
Ooc.	Oocyte.
Al. Glo.	Albuminous globule.
Th.F.E.N.	Theca folliculi nucleus.

Plate XVII

Fig. 1. Follicle showing irregularly scattered albuminous globules in the central cytoplasmic mass.
(Das's, untoned).

Fig. 2. An enlarged follicle showing a single peripheral patch of albuminous globules.
(Das's, untoned).

Fig. 3. An advanced follicle showing two peripheral patches of albuminous globules and vacuoles appearing at the periphery.
(Das's, untoned).

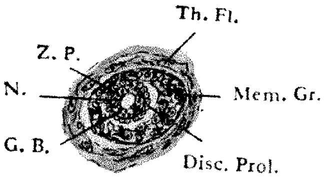
Fig. 4. A very young oocyte showing the Golgi bodies arranged mostly on the periphery.
(Ludford, bleached).

Fig. 5. A young oocyte showing the dispersal of the Golgi elements into the cytoplasm.
(Ludford, bleached).

Fig. 6. A very young oocyte showing the Golgi elements massed in a juxta-nuclear position
(Aoyama, toned).

Fig. 7. A very slightly advanced oocyte showing the perinuclear layer of Golgi.
(Aoyama, toned).

Fig. 8. An advanced oocyte showing peripheral arrangement of the Golgi elements and also the infiltration of the follicular Golgi elements into the oocyte.
(Cajal, untoned).



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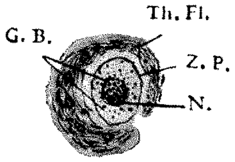

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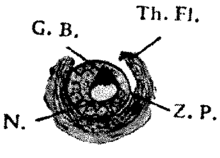

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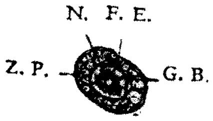

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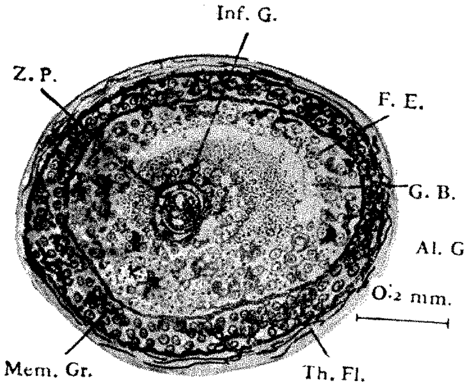

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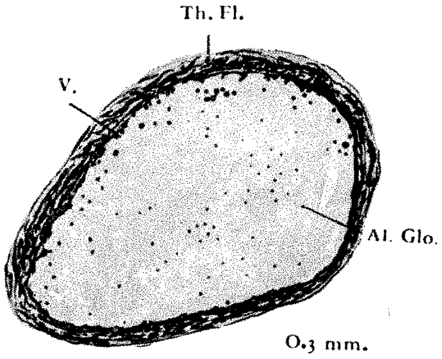

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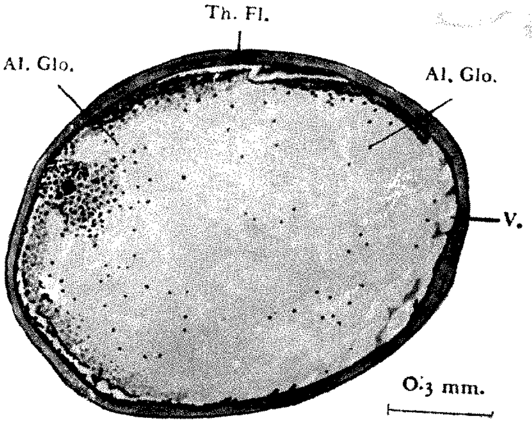

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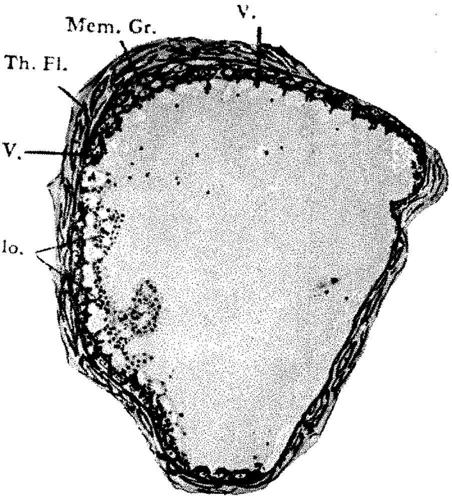

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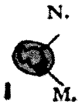
Plate XVIII

Fig. 1.	A very early oocyte showing the juxta-nuclear mass of mitochondria. (F. W. A., Iron-alum haematoxylin staining).
Fig. 2.	Oocyte showing partial perinuclear ring of mitochondria. (F. W. A., Iron-alum haematoxylin staining).
Fig. 3.	A somewhat advanced oocyte showing mitochondrial patches in the medullary region. The remnants of juxta-nuclear mass may persist o for some time. (Regaud-Tupa, acid fuchsin and aurantia staining).
Fig. 4.	An early oocyte showing peri nuclear ring of mitochondria. (Regaud-Tupa, acid fuchsin and aurantia staining).
Fig. 5.	Follicle showing uniform distribution of the albuminous globules. (Das's, toned).
Fig. 6.	Young follicle showing granular albumen more uniformly distributed except at certain isolated situations near the periphery. (Regaud-Tupa, acid fuchsin and aurantia).
Fig. 7.	The young follicle shows peripheral arrangement of the albuminous globules and the vacuoles. (Das's, untoned).



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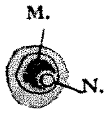

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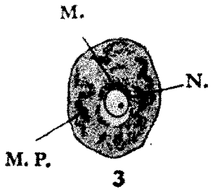

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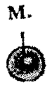

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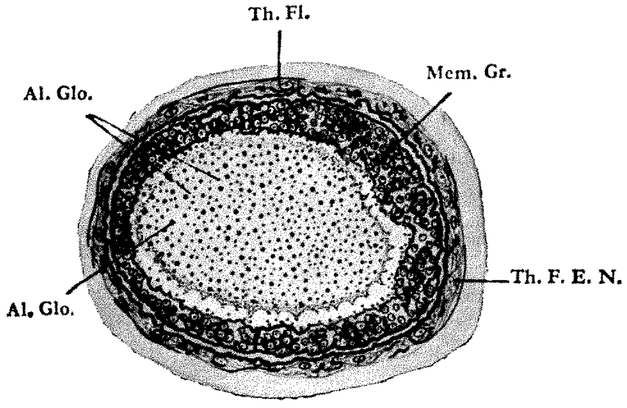

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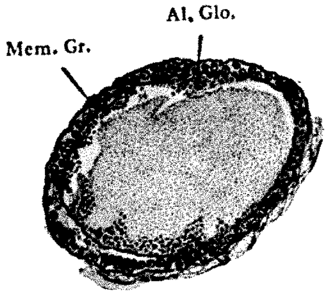

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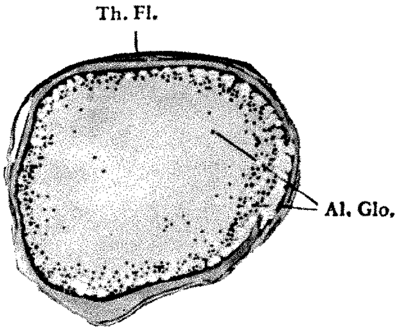

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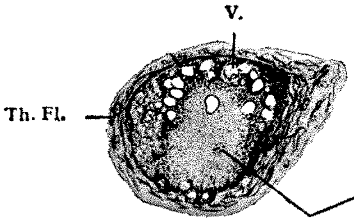
Plate XIX

Figs. 1 and 2. The young and comparatively advanced graafian follicles showing the peripheral arrangement of the vacuoles and also around the albuminous globules.
(Bouin, Mann's methyl-blue eosin staining).

Figs. 3 4 and 5. Follicles nearly of the same size showing enormous increase, in number and size, of the vacuoles resulting in a reticulated appearance of the cytoplasm. Simultameously the albuminous globules become granular.
(Bouin, Mann's methyl-blue eosin staining).



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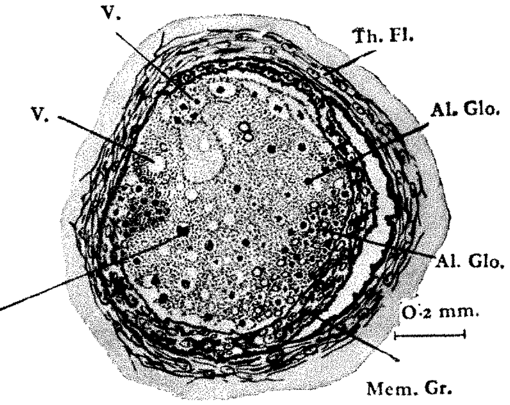

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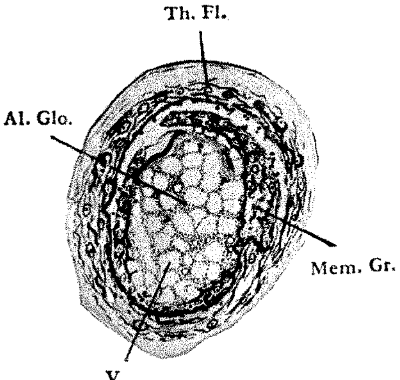

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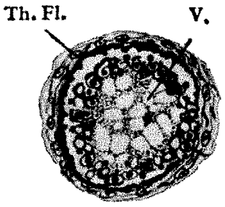

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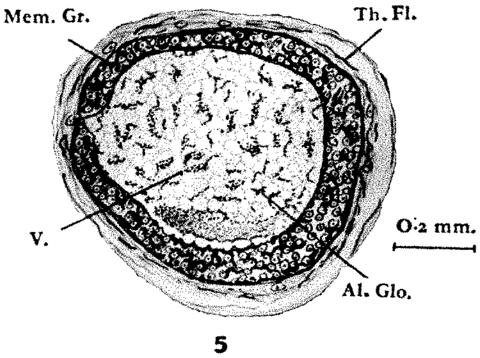

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Plate XX

Fig. 1. Shows two nuclei lying close together. Each has a prominent nucleolus.
(Bouin, Mann's methyl-blue eosin staining)

Fig. 2. Shows a polynuclear condition with three nuclei coming to lie intimately and becoming bounded by a common outer membrane.
(Bouin, Mann's methyl-blue eosin staining).

Fig. 3. Shows a stage when uninuclear condition is re-established by disintegration into finer elements of the extra nuclei.
(Bouin, Mann's methyl-blue eosin staining).

Fig. 4. A young oocyte showing a single brilliantly coloured basophil nucleolus.
(Bouin, Mann's methyl-blue eosin staining).

Fig. 5. A slightly advanced oocyte showing small spherical plasmosomes lying scattered inside the nucleus.
(Bouin, Mann's methyl-blue eosin staining).

Fig. 6. Oocyte showing the arrangement of the plasmosomal bodies on the nuclear periphery and also to some extent inside the nucleus. (Bouin, Mann's methyl-blue eosin staining).

Fig. 7. In a younger oocyte, extruded nucleolus is found to pass through the nuclear membrane and lodge itself in the cytoplasm in the immediate vicinity of the nucleus.
(Bouin, acid fuchsin and aurantia staining).

Fig. 8. A very young oocyte showing the act of passing out of plasmosomal body through the nuclear membrane. It is half inside the nucleus and half outside it.
(Bouin, iron-alum haematoxylin staining).

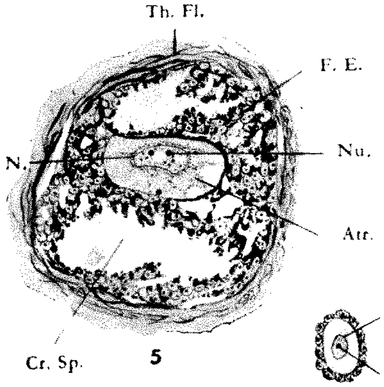
Fig. 9. Oocyte showing two nuclear bodies lying close to the nuclear membrane. The follicle cells are bigger and of vesicular type, whereas theca folliculi is characterised by thinner and drawn-out cells.
(Bouin, acid fuchsin and aurantia staining).

Fig. 10. A more advanced oocyte showing the arrangement of the extrusions midway between nuclear membrane and extreme periphery of the egg.
(Bouin, Mann's methyl-blue eosin staining).

Fig. 11. Oocyte showing the presence of a single plasmosomal body in the cortical region.
(Bouin, Mann's methyl-blue eosin staining).

Fig. 12. A young oocyte showing peripheral orientation of two prominent nucleolar extrusions. In the same figure structure of the zona radiata as having no striations or canaliculi is noticeable.
(Bouin, Mann's methyl-blue eosin staining).

Fig. 13. An advanced oocyte showing the presence of three large-sized extruded plasmosomal bodies applied to the extreme periphery of the egg. It is significant to note in these bodies an outer denser cortex and an inner clearer vesicle with a few granules.
(Bouin, Mann's methyl-blue eosin staining).



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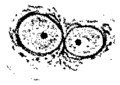

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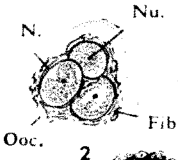

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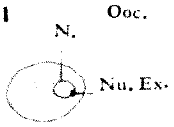

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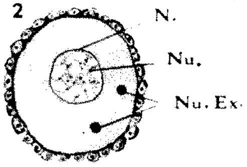

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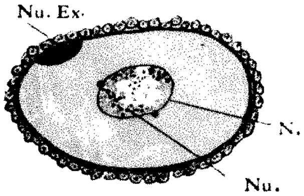

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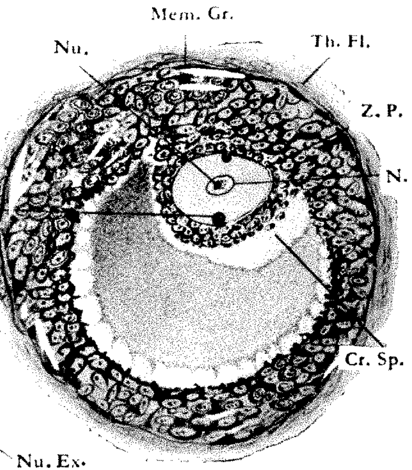

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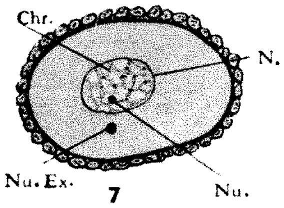

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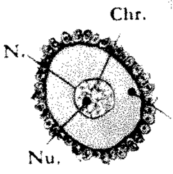

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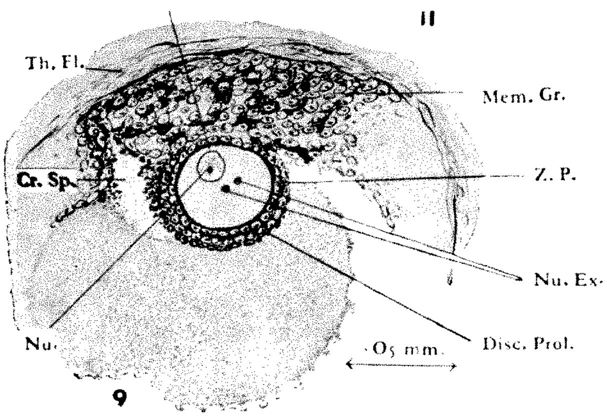

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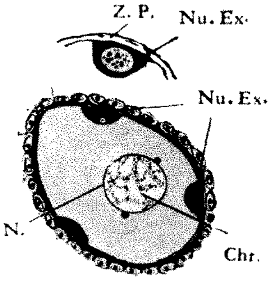

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Plate XXI

FIG. 1. An oogonium stained with neutral red showing vacuome juxta-nuclear in position.

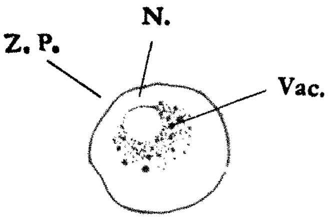
FIG. 2. A slightly older oocyte stained with neutral red and treated with osmic acid shwoing vacuome and the Golgi granules juxta-nuclear in position.

FIG. 3. An advanced oocyte stained and treated with neutral red and osmic acid showing the dispersal of vacuome and Golgi bodies into the general cytoplasm.

FIG. 4. An oogonium stained with neutral red showing the peripheral arrangement to vacuome.

FIG. 5. A young oocyte stained with Janus green B showing granular mitochondria applied to the nucleus.

FIG. 6. An old oocyte stained with Janus green B showing uniform dispersal of mitochondrial granules and also of mitochondrial patches into the cytoplasmic area.



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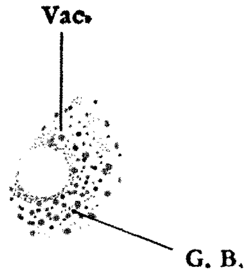

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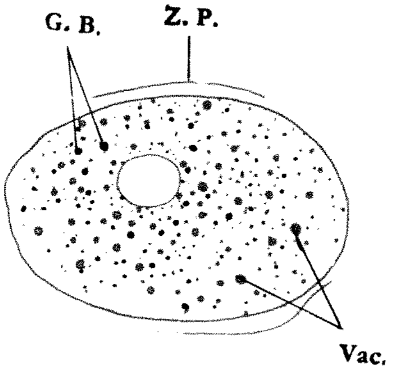

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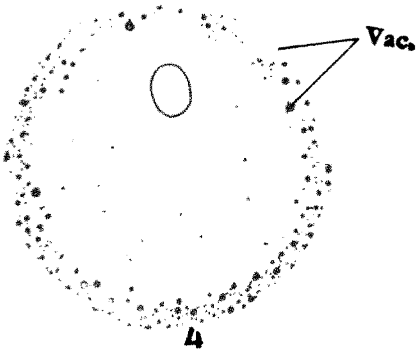

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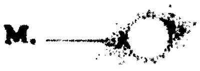

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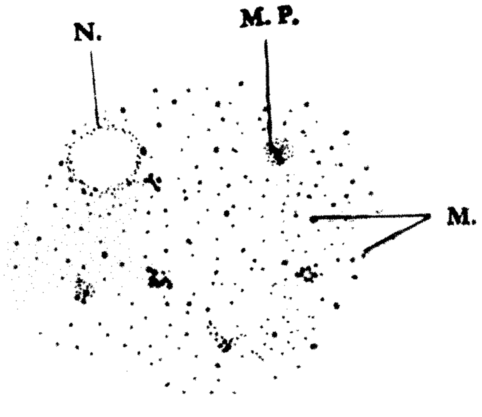

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Plate XXII

Fig. 1. Part of an ovary showing germinal epithelium, fibro-cellular stroma, primary follicles and graafian follicles. (Bouin, Mann's methyl-blue eosin staining).

Fig. 2. A very young oocyte showing Golgi apparatus juxta-nuclear in position. (Da Fano uranium-nitrate preparation—toned, unstained).

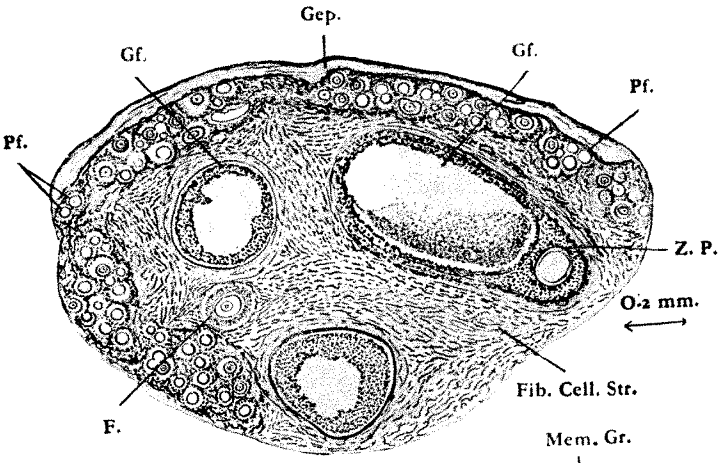
Fig. 3. A slightly advanced oogonium showing perinuclear arrangement of the Golgi bodies. (Da Fano uranium-nitrate preparation—toned, unstained).

Fig. 4. A slightly older oocyte showing the dispersal of Golgi elements into the cytoplasm. The bulk of the granules still retain their perinuclear condition.
(Aoyama, untoned).

Fig. 5. A young follicle showing the scattering of the albuminous globules of varying sizes and also of a few vacuoles in relation to them.
(Aoyama, untoned).

Fig. 6. An older follicle showing the peripheral arrangement in patches of the albuminous globules (Aoyama, untoned).

Fig. 7. An advanced follicle showing granular albumen localised to the peripheral region only. (Aoyama, untoned).



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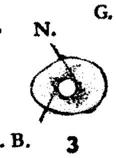

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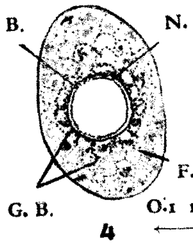

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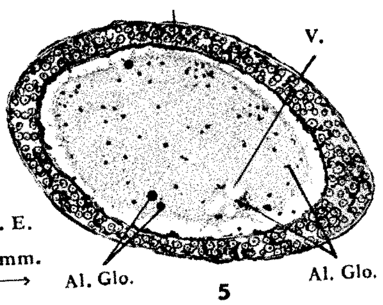

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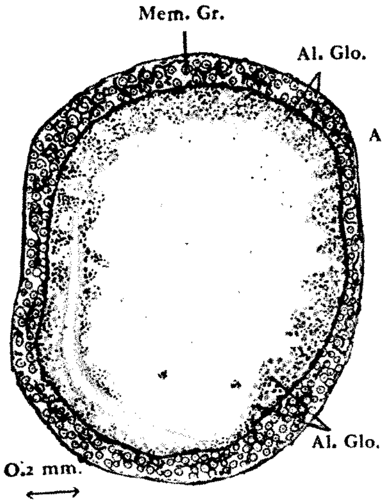

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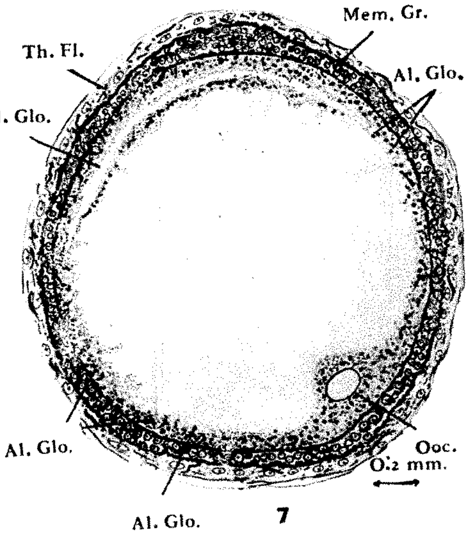

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Plate XXIII

Fig. 1. Part of an enlarged follicle showing dust-like albuminous globules and vacuoles concentrated to a particular area.
(Aoyama, untoned).

Fig. 2. A portion of the follicle showing swollen albuninous globules in clusters lying scattered into the cytoplasmic area. Presence of the albuminous globules all round the oocyte is observed in the same figure.
(F. W. A., iron-haematoxylin staining).

Fig. 3. Part of the follicle showing peripheral concentration in patches of the albuminous globules and a few sparsely scattered in the cytoplasm.
(Zenker-Helly, iron-haematoxylin staining).

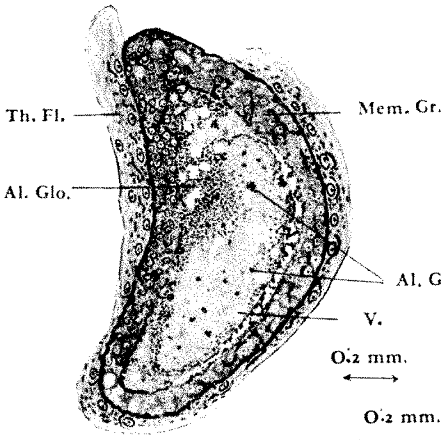
Fig. 4. An oogonium showing the infiltration of the Golgi bodies from the follicular epithelium to the egg. The zona radiata is a double-layered structure with no canaliculi. The Golgi bodies have been observed passing in the form of granules from the follicle cells to the cortical region of the egg.
(Das's toned).

Fig. 5. A very young oocyte in which the mitochondria are present closely applied to the nucleus.
(F. W. A., iron-haematoxylin staining).

Fig. 6. A slightly older oogonium showing partial perinuclear ring of the mitochondria.
(Regaud-Tupa, iron-haematoxylin staining).

Fig. 7. A young oogonium showing mitochondrial cap over the nucleus.
(Regaud—Tupa, iron-haematoxylin staining).

Fig. 8. An oocyte showing mitochondria arranged on the periphery of the nucleus.
(F. W. A., iron-haematoxylin staining).



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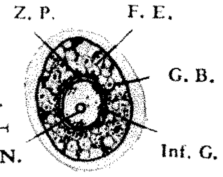

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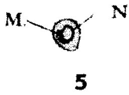

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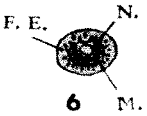

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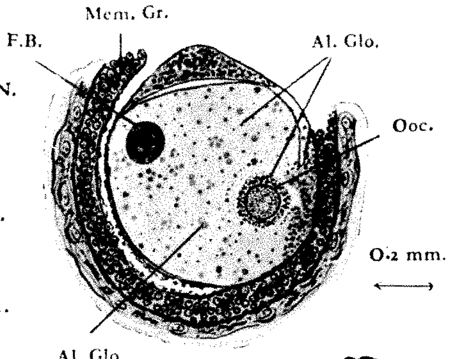

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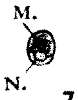

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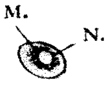

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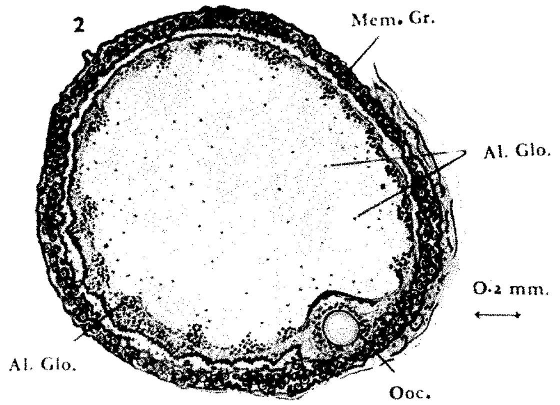

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Plate XXIV

Fig. 1. A young follicle showing peripheral arrangement of vacuoles and also the granuar condition of the albuminous globules.
(Bouin, Mann's methyl-blue eosin staining).

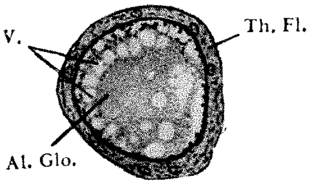
Fig. 2. A slightly advanced follicle showing larger and more numerous vacuoles filling the entire space of the cytoplasm.
(Bouin, Mann's methyl-blue eosin staining).

Fig. 3. Follicle showing albuminous globules both in the central vacuoles and their marked concentration immediately beneath the follicle cells. (Bouin, Mann's methyl-blue eosin staining).

Fig. 4. An advanced follicle showing pronounced albuminous globules in or about the vacoules and also beneath the membrana granulosa.
(Bouin, Mann's methyl-blue eosin staining).

Fig. 5. Folicle showing the outset of atretic degeneration, commencing with small connective tissue in growth from the theca folliculi pushing into the follicular wall.
(Bouin, Mann's methyl-blue eosin staining).

Fig. 6. Follicle representing a late stage of vacuolation and reticulation of the cytoplasm. The granular albumen is noticeable in the periphery of the egg.
(Bouin, Mann's methyl-blue eosin staining).



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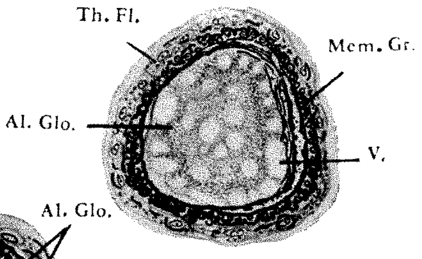

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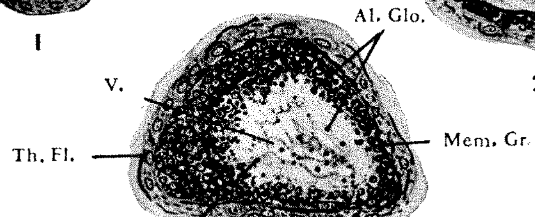

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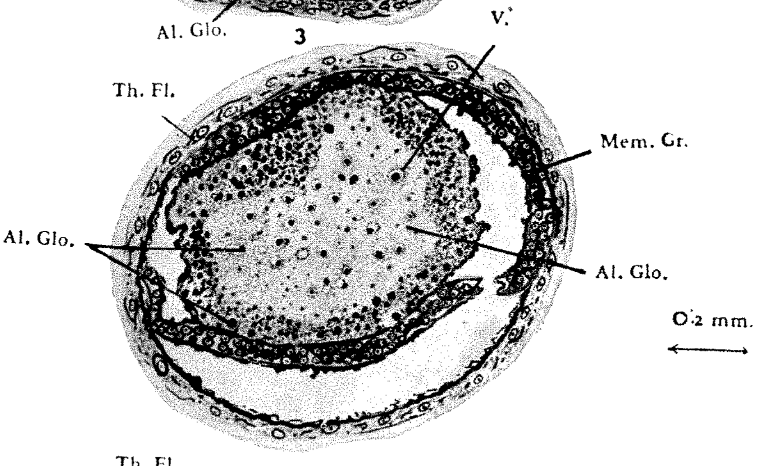

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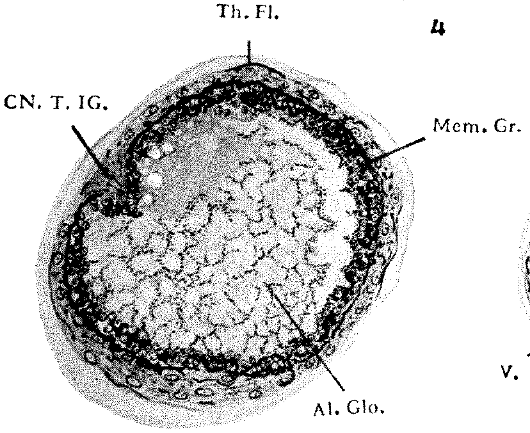

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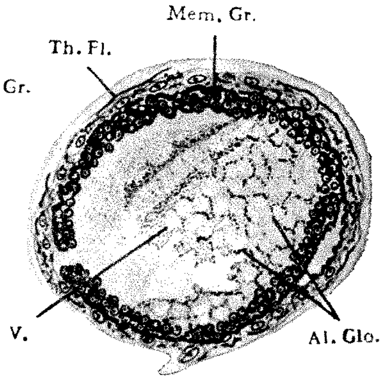


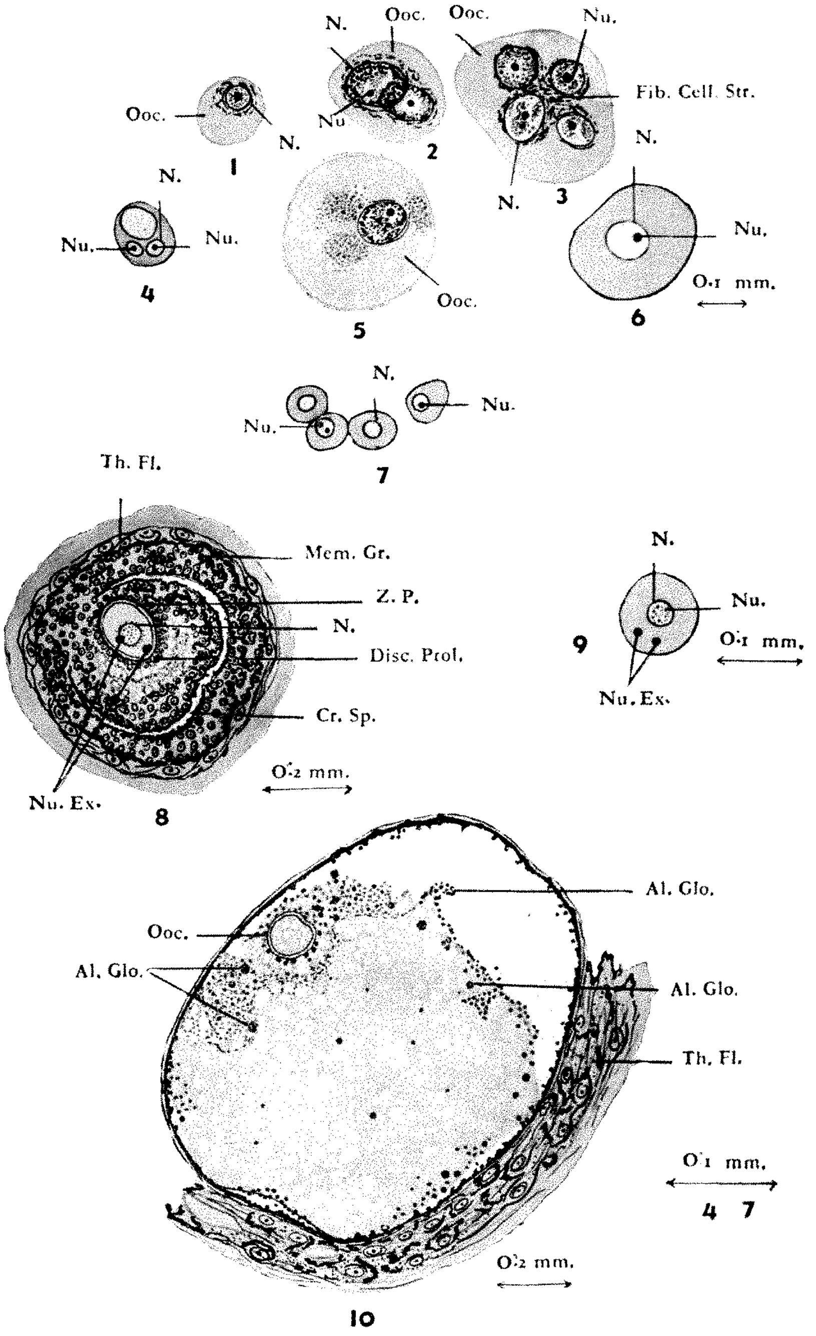
6

O·2 mm.
1 2 3

O·2 mm.
5 6

Plate XXV

Figs. 1 & 4.	Young oocytes, showing single nucleolus, usually central in position, within the nucleus. (Bouin, Mann's methyl-blue eosin staining).
Fig. 2.	Shows a binuclear stage in which a single nucleus covers a part of the other nucleus. They share a common membrane. Nucleolus in either case is quite prominent. (Bouin, Mann's methyl-blue eosin staining).
Fig. 3.	Represents a polynuclear stage in which four nuclei lie in closer alliance to each other, bounded by a common membrane. (Bouin, Mann's methyl-blue eosin staining).
Fig. 5.	Shows re-establishment of uninuclear condition by disruption of the extra nuclei. The vestigial forms of degenerated nuclei are still noticeable in the figure. (Bouin, Mann's methyl-blue eosin staining).
Fig. 6.	An oogonium showing a centrally placed nucleus with a prominent nucleolus excentric in position. (Bouin, Mann's methyl-blue eosin staining).
Fig. 7.	Shows very early oocytes in the middle one of which two nucleoli—one of them contacting nuclear periphery and the other rather deeply situated—are seen inside the nucleus. (Bouin Mann's methyl-blue eosin staining).
Fig. 8.	An advanced oocyte showing egg membranes and progressive migration of the nucleolus to the nuclear periphery. In the figure the extruding plasmosomal body is represented just almost half outside the nucleus. A prominent nucleolus lying close beneath the periphery of the egg is also seen in the same figure. Of the various membranes, the theca folliculi is represented by thinner and drawn-out cells. The follicle cells are seen as vesicular type of cells running all along the cavity of the follicle. The distinct layer of cells, all along the periphery of the egg, is known as discus proligerus. The zona radiata is a double-layered structure with no channel-like avenues or striations. (Bouin, Mann's methyl-blue eosin staining).
Fig. 9.	An oogonium showing two extruded plasmosomal bodies found almost in the middle of the medullary cortex of the egg. (Bouin, iron-haematoxylin staining).
Fig. 10.	An advanced follicle showing albuminous globules of varying sizes scattered meagrely throughout the reticulated cytoplasm and more so all round the oocyte. A few of the albuminous globules are seen clinging immediately beneath the theca folliculi, which clearly establishes their origin from the theca cells also. (Bouin, Mann's methyl-blue eosin staining).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Fib. Cell. Str.
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7
Th. Fl.
Mem. Gr.
Z. P.
N.
Disc. Prol.
Cr. Sp.
O·2 mm.
Nu. Ex.
8
N.
Nu.
9
O·1 mm.
Nu. Ex.
Al. Glo.
Ooc.
Al. Glo.
Al. Glo.
Th. Fl.
O·1 mm.
4 7
O·2 mm.
10

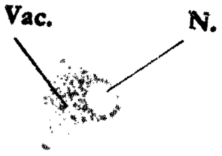
Plate XXVI

FIG. 1. An early oocyte stained with neutral red showing vacuome, stained cherry red, concentrated in a juxta-nuclear area. Inside this area are found a number of unstained refringent granules called Golgi bodies.

FIG. 2. A fairly advanced oocyte on treatment with neutral red and 2% osmic acid shows both vacuome and the Golgi bodies evenly dispersed in the cytoplasm. The Golgi bodies remain unaffected by neutral red. A large nucleus is noticeable in the same figure.

FIG. 3. An oocyte stained with Janus Green B showing uniform dispersal of mitochondria.

FIG. 4. A still older oocyte stained with Janus green B showing peripheral ring of mitochondria and a few of them dispersed throughout the cytoplasm.



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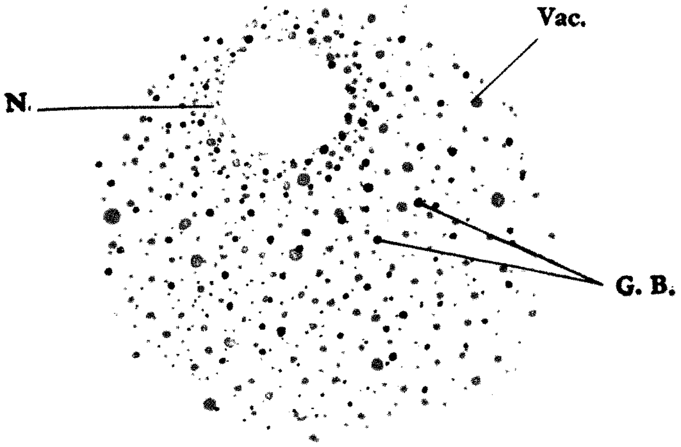

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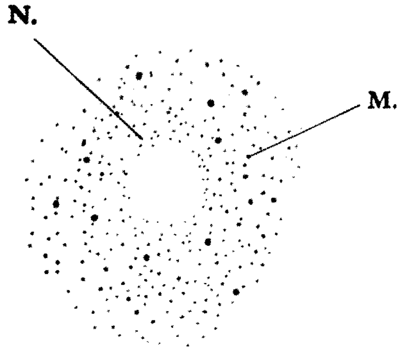

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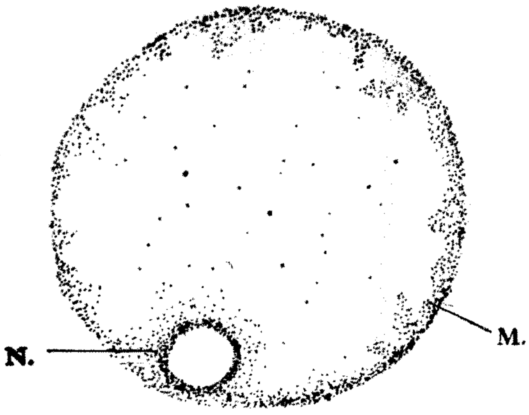


4

CONDENSATION OF MALON-o, m AND p- CHLORANILIC ACIDS WITH ALDEHYDES

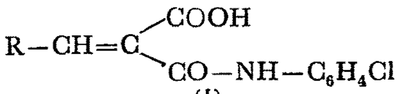
PART I.—WITH BENZALDEHYDE AND o-, m- AND p- HYDROXY-BENZALDEHYDES

By M. V. GEORGE and P. I. ITTYERAH, *Chemistry Department, St. John's College, Agra.*

In an earlier paper communicated to this (1) journal the preparations of malon-o-, m- and p-chloranilic acids has been described in detail.

This paper deals with the condensation of malon-o-, m- and p-chloranilic acids with benzaldehyde and o-, m- and p-hydroxy-benzaldehydes.

The reaction product could be either an arylidene malon chloranilic acid (1) or a coumarin chloranilide (II). Both these types are formed; the type (I) is formed when acetic acid is the condensing agent or when no condensing agent is used at all; type (II) results when condensing agents are organic bases or their salts.



$$R-CH=C\begin{cases}COOH\\CO-NH-C_6H_4Cl\end{cases}$$

(I)

$$R-CH=CH-CO-NH-C_6H_4Cl$$

(II)

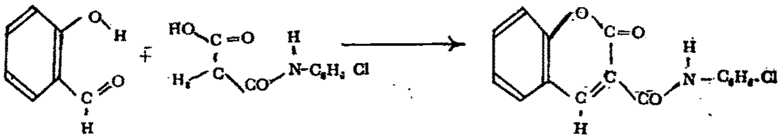
Benzaldehyde reacted fairly well with all the three malon chloranilic acids. Malon-o-chloranilic acid gave the highest yields of both the acid and cinnam-chloranilide products (Acid 92%; chloranilide 99%), while the yields from malon-m-chloranilic acid were the lowest (Acid 70%; chloranilide 90%). Malon-p-chloranilic acid gave 81% of the acid derivative and 97% of the chloranilide respectively.

Among the three monohydroxy-benzaldehyde the m-isomer was found to be more reactive and the yields of both the acid and the chloranilide derivatives were higher than those obtained from other two isomers.

In the p-hydroxy-benzaldehyde condensation the yields of the chloranilide derivatives formed, were comparable to those obtained from the m-isomer, but the acid products were formed in very poor yield. Similar observations were made in the condensation of this aldehyde with malon anilic acid (2) and the three malon toluidic acids (3) by previous workers. This probably points to the unstable nature of these acid products under the experimental conditions observed in these condensations.

With salicylaldehyde, as expected, the choranilides of coumarin-3-carboxylic acid (III) are formed.

The highest yield of the coumarin (56%) was obtained from malon-p-chloranilic acid condensation. Another observation made during these experiments, was regarding the formation of deep yellow or orange coloured products in appreciable quantities along with the expected coumarins. These products were very soluble in common organic solvents like alcohol, acetone and ether and they melted at lower temperatures compared to those of the coumarin derivatives. They gave violet colouration with ferric chloride solution and appear to be 2-hydroxy-benzal chloranilines.



The formation of 2-hydroxy benzal-chloranilines seems to be a peculiar feature of the o-hydroxy-aldehyde condensations alone. The yields of the products from the salicylaldehyde condensations were comparably poor and as a whole it seems that the hydroxy group in the ortho positions exerts a sort of inhibiting influence.

EXPERIMENTAL

The general procedure had been to mix equimolecular quantities of the acid and aldehyde in a small round-bottomed flask and heat on a water bath. When glacial acetic acid was used as the condensing agent, 1 molar proportion was added, but organic bases were used only in traces (0. 15 mol.). After heating for the required length of time usually 4 hrs.), the contents were extracted with a strong solution of sodium bicarbonate. The acid products were dissolved by the alkali, while the non acid residue left was filtered and purified by recrystallization from suitable organic solvents like alcohol and acetone. The alkali extract on acidification with hydrochloric acid yielded the acid products which were further purified by recrystalization from alcohol or acetone. All the products obtained were white crystalline substances except those from salicylaldehyde.

In the case of salicylaldehyde, the method of extraction had slightly to be altered. On treatment of the condensed mass with sodium bicarbonate solution there was practically very little reaction and the alkali extract on acidification with hydrochloric acid gave no acid product. The residue left was treated with hot alcohol when the Schiff bases dissolved giving orange-coloured solutions and on cooling the alcohol extract crystals of 2-hydroxy benzal chloranilines separated out. Further purification was effected by recrystallization from alcohol. The residue left after alcohol extraction was purified by recrystallization from acetic acid. The coumarins thus obtained were pale yellow and melted at comparatively higher temperatures.

All the products were analysed and the results are shown in the table below.

TABLE I

No.	Name	Mol. Formula	m. p.	Eq. wt.		Chlorine (%)		Nitrogen (%)	
			oC	Found	Calculated	Found	Calculated	Found	Calculated
1.	Benzylidene malon-o-chloranilic acid.	$C_{16}H_{12}O_3NCl$	189° (d)	302.9	301.5	11.71	11.76		
2.	Cinnam-o-chloranilide.	$C_{15}H_{12}ONCl$	138			13.54	13.55		
3.	Benzylidene malon-m-chloranilic acid.	$C_{16}H_{12}O_3 NCl$	197.5 (d)	300.9	301.5	12.1	11.76		
4.	Cinnam-m-chloranilide.	$C_{15}H_{12}ONCl$	120			14.27	13.27		
5.	Benzylidene malon-p-chloranilic acid.	$C_{16}H_{12}O_3NCl$	225 (d)	299.8	301.5	12.05	11.76		
6.	Cinnam-p-chloranilide.	$C_{15}H_{12}ONCl$	185.5			13.61	13.77		
7.	Coumarin-3-carboxy-o-chloranilide.	$C_{16}H_{16}O_3 NCl$	230					4.72	4.67
8.	2-hydroxy benzal-o-chloraniline.	$C_{16}H_{10}O_3 NCl$	86					6.38	6.04
9.	Coumarin-3-carboxy-m-chloranilide.	$C_{16}H_{10}O_3 NCl$	240			11.98	11.84		
10.	2-hydroxy-benzal-m-chloraniline.	$C_{13}H_{10}ONCl$	95					6.22	6.04
11.	Coumarin-3-carboxy-p-chloranilide.	$C_{16}H_{10}O_3 NCl$	250			12.27	11.84		
12.	2-hydroxy benzal-p-chloraniline.	$C_{13}H_{10}ONCl$	106					6.19	6.04
13.	m-hydroxy benzylidene malon-o-chloranilic acid.	$C_{16}H_{12}O_4 NCl$	189 (d)	316.4	317.6			4.42	4.40
14.	m-hydroxy cinnam-o-chloranilide.	$C_{15}H_{12}O_2 NCl$	173					5.12	5.11
15.	m-hydroxy benzylidene-malon-m-chlor-anilic acid.	$C_{16}H_{12}O_4 NCl$	192 (d)	315.9	317.16	11.3	11.16		
16.	m-hydroxy cinnam-m-chloranilide.	$C_{15}H_{12}O_2 NCl$	190			13.27	12.96		
17.	m-hydroxy benzylidene-malon-chloranilic acid.	$C_{16}H_{12}O_4 NCl$	221 (d)	317.4	317.6	11.07	11.16		

No.	Name	Mol. Formula	m. p. oC	Eq. wt.		Chlorine (%)		Nitrogen (%)	
				Found	Calculated	Found	Calculated	Found	Calculated
18.	m-hydroxy cinnam-p-chloranilide.	$C_{15}H_{12}O_2$ NCl	208			12.77	12.96		
19.	p-hydroxy benzylidene-m-o-chloranilic acid.	$C_{16}H_{12}O_4$ NCl	205 (d)	317.3	317.6			4.52	4.40
20.	p-hydroxy cinnam-o-chloranilide.	$C_{15}H_{12}O_2$ NCl	184.5					5.14	5.11
21.	p-hydroxy benzylidene-malon-m-chloranilic acid.	$C_{16}H_{12}O_2$ NCl	202 (d)	318.3	317.6	11.34	11.16		
22.	p-hydroxy cinnam-m-chloranilide.	$C_{15}H_{12}O_2$ NCl	200			13.32	12.96		
23.	p-hydroxy benzylidene malon-p-chloranilic acid.	$C_{16}H_{12}O_4$ NCl	226 (d)	321	317.6	10.98	11.16		
24.	p-hydroxy cinnam-p-chloranilide.	$C_{15}H_{12}O_2$ NCl	223			12.6	12.96		

SUMMARY

Malon-o-, m- and p- chloranilic acids were condensed with benzaldehyde and o-, m- and p-hydroxy-benzaldehydes both in the absence of condensing agent and also with the use of condensing agents like acetic acid and of traces of organic bases like pyridine, piperidine, 2, 4-lutidine, collidine, triethanol amine or traces of their salts like pyridine acetate and piperidine acetate. The condensing agents used were found to catalyse the reactions. Salicylaldehyde gave the corresponding coumarin-3-carboxy-chloranilides and 2-hydroxy-benzal-chloranilines. The other aldehydes gave the corresponding benzylidene malon chloranilic acids and the cinnam chloranilides.

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CONDENSATION OF MALON-o-, m- and p- CHLORANILIC ACIDS WITH ALDEHYDES

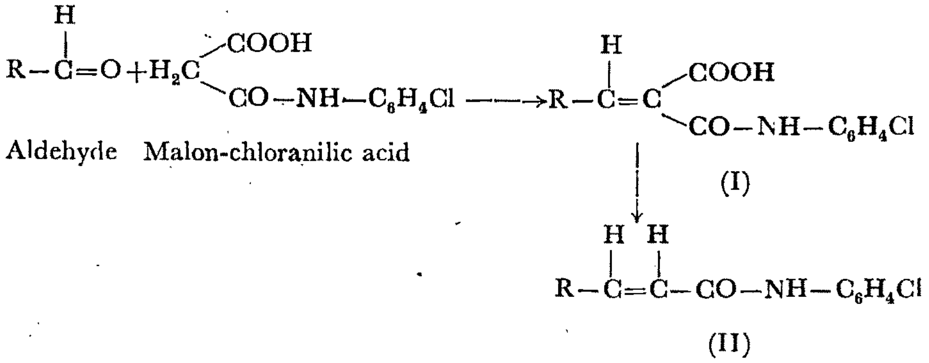
PART II.—WITH O- AND P-METHOXY BENZALDEHYDES AND m-METHYL BENZALDEHYDE

By M. V. GEORGE and P. I. ITTYERAH, *Chemistry Department, St. John's College, Agra.*

The condensations of malonic acid with methoxy-benzaldehydes in the presence of organic bases like pyridine and piperidine have been studied by Pandya and Vahidy (5, 6). The reaction of the same aldehydes with malonainlic acid and the three malon-toluidic acids has been reported by Ittyerah and Pandya (2, 3). Methyl benzaldehydes (m- and p-) have been condensed with malonic acid by Pandya, Agarwal and Tripathi (4), with malonanilic acid and malon-toulidic acids by Ittyerah (unpublished) and with malon-1, 3, 4-xylidic acid by Ittyerah and Chellappa (1).

The present paper deals with the condensation of malon-o-, m- and p-chloranilic acids with o- and p-methoxy-benzaldehydes and m- methyl benzaldehyde.

The condensations have been carried out under various conditions. Two products generally formed were the arylidene malon-chloranilic acid (I) and the cinnam-chloranilide (II).



$$R-\overset{H}{\overset{|}{C}}=O+H_2C\begin{matrix}\nearrow COOH\\ \searrow CO-NH-C_6H_4Cl\end{matrix}\longrightarrow R-\overset{H}{\overset{|}{C}}=C\begin{matrix}\nearrow COOH\\ \searrow CO-NH-C_6H_4Cl\end{matrix}$$

$$\downarrow$$

$$R-\overset{H}{\overset{|}{C}}=\overset{H}{\overset{|}{C}}-CO-NH-C_6H_4Cl$$

The type (I) products were formed either in the entire absence of condensing agents or when glacial acetic acid was used. The use of traces of organic bases as condensing agents induced decarboxylation and products of the type (II) were obtained. Malon-m-chloranilic acid with m-methyl benzaldehyde gave only m-methyl benzylidene malon-m-chloranilic acid. Attempts to prepare the cinnam-chloranilide of the type II were not successful.

All earlier experiments have shown that the presence of a hydroxyl group in the aldehyde molecule exerts an inhibitive influence on the activity of the aldehyde group. This is most noticeable when the hydroxy group is in the ortho position to the aldehyde group.

TABLE I

No.	Name	Mol. Formula	M. p.	Eq. Wt.		Chlorine		Nitrogen	
				Found	Calculated	Found	Calculated	Found	Calculated
1.	o-methoxy benzylidene malon-a-chloranilic acid	$C_{17} H_{14} O_4 NCl$	184.5° C(d)	331.5	331.6			4.33	4.22
2.	o-methoxy cinnam o-chloranilide	$C_{16} H_{14} O_2 NCl$	126° C					4.87	4.86
3.	o-methoxy benzylidene malon-m-chloranilic acid	$C_{17} H_{14} O_4 NCl$	232° C(d)	331.1	331.6	10.87	10.69		
4.	o-methoxy cinnam-m-chloranilide.	$C_{16} H_{14} O_2 NCl$	127° C			12.17	12.33		
5.	o-methoxy benzylidene malon-p-chloranilic acid	$C_{17} H_{14} O_4 NCl$	225° C(d)	331.9	331.6	10.84	10.69		
6.	o-methoxy cinnam-p. chloranilide	$C_{16} H_{14} O_2 NCl$	182° C			12.19	12.33		
7.	p-methoxy benzylidene malon-o-chloranilic acid.	$C_{17} H_{14} O_4 NCl$	206° C (d)	331.9	331.6			4.23	4.22
8.	p-methoxy cinnam-o-chloranilide.	$C_{16} H_{14} O_2 NCl$	157° C					4.78	4.86
9.	p-methoxy benzy lidene malon-m-chloranilic acid	$C_{17} H_{14} O_4 NCl$	198° C (d)	332.4	331.6	10.58	10.69		
10.	p-methoxy cinnam m-chloranilide.	$C_{16} H_{14} O_2 NCl$	131° C			12.21	12.33		
11.	p-methoxy benzylidene maonn-p-chloranilic acid	$C_{17} H_{14} O_4 NCl$	208.5° C(d)	333.5	331.6	10.58	10.69		
12.	p-methoxy cinnam-p-chloranilide.	$C_{16} H_{14} O_2 NCl$	176° C			12.02	12.33		
13.	m-methyl benzylidene malon-o-chloranilic acid.	$C_{17} H_{14} O_3 NCl$	187° C (d)	315.3	315.65			4.43	4.43
14.	m-methyl cinnam-o-chloranilide.	$C_{16} H_{14} O NCl$	104° C					5.10	5.07
15.	m-methyl benzylidene malon-m-chloranilic acid	$C_{17} H_{14} O_3 NCl$	177° C (d)	316.1	315.65			4.50	4.43
16.	m-methyl benzylidene malon-p-chloranilic acid	$C_{16} H_{14} O_3 NCl$	202° C (d)	314.6	315.65	11.42	11.23		
17.	m-methyl cinnam-p-chloranilide.	$C_{16} H_{14} O NCl$	176° C					5.18	5.07

TABLE II showing the maximum yields of the products obtained.

Aldehyde	Malon-o-chloranilic acid		Malon-m-chloranitic Acid		Malon-p-chloranilic acid.	
	Acid yield%	Cinnam-chloranilide. yield%	Acid yield%	Cinnam-chloranilide. yield%	Acid yield%	Cinnam-chloranilide. yield%
o-Methoxy benzaldehyde	70.8	89	70.8	89.1	74	96.5
p-Methoxy benzaldehyde	70.8	96.5	64.4	89.1	64.4	96.5
m-Methyl henzaldehyde	74.4	90.4	67.7	(no product)	88	90.4

O-Methoxy benzaldehyde when condensed with malon-o-chloranilic acid gave 71% of o- methoxy-benzylidene Malon-o-chloranilic acid and 89% yield of o-methoxy cinnam-o-chloraintide, under different conditions. P-methoxy benzaldehyde gave 71% of the acid product and 97% of the cinnam-chloranilide derivative, when condensed with malon-o-chloranilic acid. Similar observations were made in the cases of malon-m-and p-chloranilic acids also. Thus it was found that the hydroxy group when replaced by a methoxyl, the reactivity of the aldehyde group increases, giving better yields of the products.

Of the three mono methyl benzaldehydes only the m-isomer has been condensed with malon-chloranilic acids. Fairly good yields of the products were obtained. Malon-p-chloranilic acid gave the maximum yields of both the acid and the chloranilide derivatives. The methyl group in the meta position of the aldehyde molecule inhibited the reaction in the cases of both malonic acid and malonanilic acid condensations as reported by previous workers, but with the malon-chloranilic acids the retarding effect is not appreciable.

EXPERIMENTAL

The general procedure has been to mix equimolecular quantities of the acid and aldehyde in a round-bottomed flask and heat on a water bath. Acetic acid when used as condensing agent was added in molecular proportion (1 mole) but organic bases were used only in traces (0.15 mole). After heating for the required length of time the contents of the flask were extracted with a strong solution of sodium bicarbonate. The acid products were dissolved by the alkali. The non-acid-residue was filtered and purified by recrystallization from suitable organic solvents like alcohol and acetone. The alkali extract on acidification with hydrochloric acid yielded the acid products which were further purified by recrystallization from alcohol or acetone.

All the products were white, crystalline substances. They were analysed and identified and the results shown in Table I. Table II shows the maximum yields of the products formed in each case.

SUMMARY

Malon--o-,m- and p-chloranilic acids were condensed with o-and p-methoxy benzaldehydes and m-methyl benzaldehyde. The corresponding arylidene-malon-chloranilic acids and the cinnam chloranilides were obtained. From malon-m-chloranilic acid and m-methyl benzaldehyde condensation, only m-methyl benzylidene malon-m-chloranilic acid could be isolated, various condensing agents were tried. Acetic acid in mol. proportion and pyridine acetate or piperidine acetate in traces (0.15 mole) were found to be good catalysts in these reactions.

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ABSORPTION OF IRON BY WHEAT PLANTS WHEN SUPPLIED AT DIFFERENT STAGES OF GROWTH

By R. M. Singh, *Department of Agronomy, B. R. College, Agra, India.*

Introduction

Growth of wheat plants is markedly affected by the absence of any of the essential elements from the nutrient source. Gericke (1) and Brenchley (2) investigated the requirements of wheat and barley respectively for major elements during various phases of plant growth. Very little work has been done on the response of wheat plants to varying concentrations of minor elements at successive stages of growth. Only Gericke (1) has stressed the effect of the absence of iron on the wheat plant in culture solutions when it was deprived of it after a certain growth in the complete nutrient solution. Information in this regard is lacking that how long the supply of iron to the plants in the substrate is essential and also the critical period of the life cycle when this element must be present. Therefore, the present investigation was started to study the critical period of the life cycle when plants need iron most and the concentration of iron that could be employed in the media without any detrimental effect on plant growth.

Technique and Material

Plants were cultured in pyrex containers of 500 c.c. capacity. The culture solution was prepared by dissolving the salts (A. R. grade) in re-distilled water (distilled in pyrex sets). Knop's (3) modified schedule was followed in preparing the culture solution except that of iron (ferric tartarate) which was supplied according to the plan of the experiment. The pH of the media ranged between 5.0 to 5.4 Solutions in the containers were renewed at weekly intervals in the early stages (upto 40 days) followed by twice a week in the later part of the life cycle, but the volume was made good each day by adding redistilled water equal to the amount transpired. Aeration was done on each alternate day by bubbling air near the roots in order to avoid any fungal growth. Cultures were maintained in a small green house.

Seeds were germinated on petri dishes covered with fine nettings to allow unhampered germination and to facilitate the removal of individual seedlings with roots. Five to seven days old seedlings were dissected out to deprive them of the endosperm and were transplanted to the containers. Two seedlings were set in each culture. Plants were grown for 120 days in 1950-1, 100 days in 1951-2 and 120 days in 1952-53.

Experiments were conducted for three consecutive years. The plans of the experiments were as in Table 1.

TABLE I.

1950-1

Period in days	Fe (0.0 p.p.m.) followed by Fe_1 (12.91 p.p.m.)			Fe_1 (12.91 p.p.m.) followed by Fe_0 (0.0.p.p.m.)			Fe_2 (25.82 p.p.m.) followed by Fe_0 (0.0.p.p.m.		
	Treatments			*Treatments*			*Treatments*		
	1	2	3	4	5	6	7	8	9
PI.-40	—	—	—	+	+	+	+	+	+
40-80	+	—	—	—	+	+	—	+	+
80-120	+	+	—	—	—	+	—	—	+

1951-2

Period in days	Fe_0 (0.0 p. p. m.) followed by Fe_1 (12.91 p.p.m.)					$Fe_{\frac{1}{2}}$ (6.45 p. p. m.) followed by Fe_0 (0.0 p.p.m.)					Fe_1 (12.91 p. p. m.) followed by Fe_0 (0.0 p.p.m.)				
	Treatments					*Treatments*					*Treatments*				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pl.—20	—	—	—	—	—	+	+	+	+	+	+	+	+	+	+
20-40	+	—	—	—	—	—	+	+	+	+	—	+	+	+	+
40-60	+	+	—	—	—	—	—	+	+	+	—	—	+	+	+
60-80	+	+	+	—	—	—	—	—	+	+	—	—	—	+	+
80-100	+	+	+	+	—	—	—	—	—	+	—	—	—	—	+

1952-3

Period in days	Fe_0 (0.0 p.p.m.) followed by $Fe_{\frac{1}{2}}$ (6.45 p.p.m.)						$Fe_{\frac{1}{2}}$ (3.22 p.p.m.) followed by Fe_0 (0.0 p.m.)						$Fe_{\frac{1}{2}}$ (6.45 p.p.m.) followed by Fe_0 (0.0 p.p.m.)					
	Treatments						*Treatments*						*Treatments*					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pl.—20	—	—	—	—	—	—	+	+	+	+	+	+	+	+	+	+	+	+
20-40	+	—	—	—	—	—	—	+	+	+	+	+	—	+	+	+	+	+
40-60	+	+	—	—	—	—	—	—	+	+	+	+	—	—	+	+	+	+
60-80	+	+	+	—	—	—	—	—	—	+	+	+	—	—	—	+	+	+
80-100	+	+	+	+	—	—	—	—	—	—	+	+	—	—	—	—	+	+
100-120	+	+	+	+	+	—	—	—	—	—	—	+	—	—	—	—	—	+

+indicates with iron; —indicates without iron.
Pl. Planting.

The results of the first year's experiment indicated that lower concentration of iron showed beneficial effect; therefore, it was thought necessary to study the effects of still lower concentrations in the succeeding years. A period of 40 days for initial presence and absence of iron was also too long to detect the critical period of its presence; this was, therefore, reduced to 20 days in subsequent years.

Growth was measured in terms of dry matter (shoot) per plant. Ten plants from each treatment in all the experiments were taken, well cleaned in slightly acidulated water to wash out the dust adhered to plant parts and dried at 100° C to constant weight for recording the dry matter. Iron was estimated following the method of Bandemer and Shaible (4) in duplicates or triplicates using a colorimeter. The statistical analyses of the data are done following Yates (5).

EXPERIMENTAL RESULTS

It is evident from the data (Table II) that the application of iron significantly (1%) increased the growth of plants in all the years over control, but the two levels of iron did not show any significant difference between them, though, there was an indication of increased dry matter production at lower concentrations. It further reveals that the absorption of iron increased with increase in the concentration of this element in the medium. Comparing the two levels of iron in each of the experiments, it comes out that higher concentration of iron in the medium increased the iron content of plants. In 1951-2 due to unfavourable weather conditions plants in some treatments did not survive beyond 100 days, therefore, it was deemed necessary to harvest the whole of the experiment twenty days earlier than in other years, thus the total dry matter produced was less and also the iron absorption than the treatments in other years. Fe_0 (no iron) level in all the years produced very low dry matter and correspondingly contained very little iron. This small amount may be attributed to the fact that the plants might have absorbed certain quantity of iron at their seedling stage from their endosperms, before transferring to the cultures after which the supply of iron was totally stopped.

Data in Table III depict the effect of increasing levels of iron on dry matter (shoot) production and their iron content by plants when iron was supplied initially for durations of varying periods and then withheld. Plants supplied with iron initially for duration of 40 days or more produced significantly more dry matter than plants deprived of iron. Initial supply of iron for 20 days only, did not increase significantly as compared with control (1951-2 and 1952-3). It is, thus, evident that wheat plants need an initial supply of iron at least for a period of 40 days. Longer initial periods of iron supply beyond 80 days were not significant in their effects. Increasing the concentration of iron, in all the

TABLE II. *Effect of Levels of Iron on the Dry Matter Production and Iron content of Plants (Shoots)*

1950-1			1951-2			1952-3		
Levels of iron	D. W. (gm.)	Fe content (p.p.m.)	Levels of iron	D. W. (gm.)	Fe content (p.p.m.)	Levels of iron	D. W. (gm.)	Fe content (p.p.m.)
Fe_0	0.156	12	Fe_0	0.138	10	Fe_0	0.155	12
Fe_1	1.100	210	$Fe_{\frac{1}{2}}$	0.810	132	$Fe_{\frac{1}{4}}$	2.138	181
Fe_2	1.060	216	Fe_1	0.772	151	$Fe_{\frac{1}{2}}$	2.110	197
C. D. 1%	0.107		C. D. 1%	0.134		C. D. 1%	0.337	
5%	0.097		5%	0.102		5%	0.257	

TABLE III *Final Dry Matter Production (gm.) and Iron Content of Plants as influenced by Initial Periods of Iron Supply followed by its Absence*

Initial supply of iron in days followed by Fe$_0$	1950-1				1951-2				1952-3			
	Fe$_1$(12.91 p. p. m.)		Fe$_2$ (25.82 p. p. m.)		Fe$_{\frac{1}{2}}$ (6.45 p. p. m.)		Fe$_1$ (12.91 p. p. m.)		Fe$_{\frac{1}{4}}$ (3.22 p. p. m.)		Fe$_{\frac{1}{2}}$ (6.45 p. p. m.)	
0.0ppm.)	D. W. (gm.)	Fe. cont. (ppm.)	D. W. (gm.)	Fe. cont. (ppm.)	D. W. (gm.)	Fe. cont. (ppm.)	D. W. (gm.)	Fe. cont. (ppm.)	D. W. (gm.)	Fe. cont. (ppm.)	D. W. (gm.)	Fe. cont. (ppm.)
0	0.156	12	0.156	12	0.138	10	0.138	10	0.155	12	0.155	12
20	—	—	—	—	0.169	25	0.174	54	0.197	28	0.195	29
40	0.336	76	0.386	85	0.293	71	0.292	82	0.432	64	0.423	68
60	—	—	—	—	0.610	102	0.582	121	1.280	123	1.231	128
80	0.966	148	0.960	160	0.780	120	0.719	138	1.992	142	1.972	156
100	—	—	—	—	0.810	132	0.772	151	2.047	177	2.096	189
120	1.100	210	1.060	216	—	—	—	—	2.138	181	2.110	197
C. D. 1%	0.107				0.134				0.337			
5%			0.097				0.102				0.257	

experiments, did not affect significantly the dry matter production, for any of the periods of supply. Iron content in plants irrespective of concentrations of this

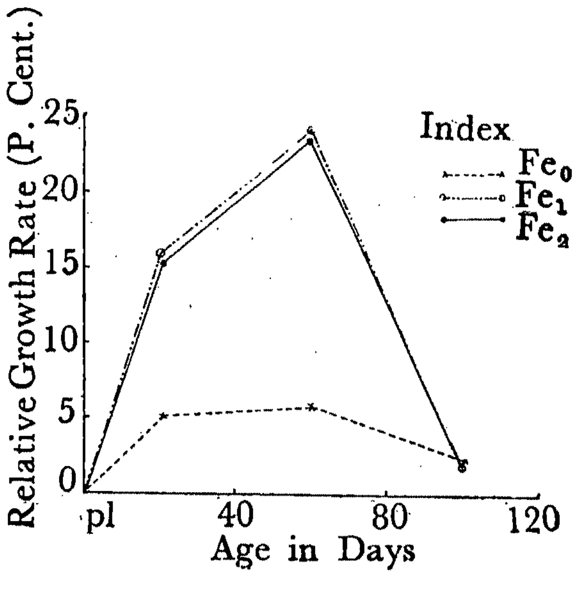

Fig. 1. Relative growth-rate (percent) as influenced by the concentrations of iron supplied throughout the life-cycle.

element in the medium increased with increase in the period of initial supply but this increase was more upto 80 days followed by a small increase in the iron content of plants. Reduced period of initial supply of iron was associated with low dry matter production and low iron content. Higher concentration of iron in the medium increased its content in plants, and depressed the dry matter production, and plants supplied with lower concentration were associated with high dry matter production and comparatively low iron content.

TABLE IV. *Effect of Initial Absence of Iron followed by its Presence on the Dry Matter Production and its Iron Content.*

1950-1			1951-2			1952-3		
Initial absence of Fe in days followed by Fe_1 (12.91 p. p. m.)	D. W. (Mean) (gm.)	Fe content (p. p. m.)	Initial absence of Fe in days followed by Fe_1 (12.91 p. p. m.)	D. W. (Mean) (gm.)	Fe content (p. p. m.)	Initial absence of Fe in days followed by Fe (6.45 p. p. m.)	D. W. (Mean) (gm.)	Fe content (p. p. m.)
0	1.100	210	0	0.772	151	0	2.110	197
20	—	—	20	0.694	137	20	2.089	188
40	1.000	146	40	0.550	92	40	1.910	138
60	—	—	60	0.326	69	60	0.781	87
80	0.358	38	80	0.164	23	80	0.255	36
100	—	—	100	0.138	10	100	0.164	16
120	0.156	12	120	—	—	120	0.155	12
C. D. 1%	0.107		C. D. 1%	0.131		C. D. 1%	0.337	
5%	0.097		5%	0.102		5%	0.257	

As the periods of initial absence increased (Table IV), there were corresponding decreases in the dry matter and its iron content. If this period of initial deprivation of iron was extended beyond 60 days, the supply after this did not produce any significant effect; however, the lack of iron in the first 40 days did not reduce the dry matter appreciably except in 1951-2 where, after an initial absence of iron for 40 days plants could not get sufficient time for growth. Iron content was markedly affected by the initial absence of this element in the medium; deprivation of iron for more than 20 days reduced its absorption appreciably. After an initial absence for a specified period, supply of $Fe\frac{1}{2}$ (6.45 p. p. m.) proved nearly as effective as the higher dose ($Fe_1 = 12.91$ p. p.m.) in all respects.

Relative growth rate calculated in terms of percentage under culture conditions have been depicted in Fig. 1 for 1950-1, Fig. 2 for 1951-2 and Fig. 3 for 1952-3, to follow the trend of growth as influenced by different concentrations of iron. It is evident that the rate of increment in growth increased upto 80 days and then suddenly decreased except in control where the maximum increment was observed between 40 and 60 days of the life cycle, due, probably, to premature symptoms of death of plants. This studied in conjunction with the effect of iron supply at different stages of growth, brings out the fact that the

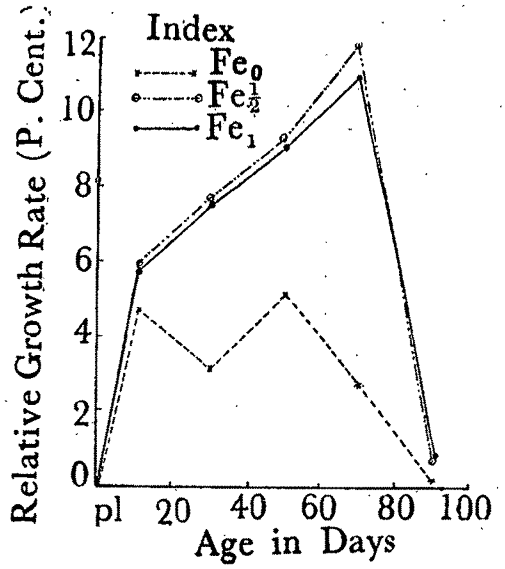

Fig 2. Relative growth rate (per cent) as influenced by the concentration of iron supplied throughout the life cycle.

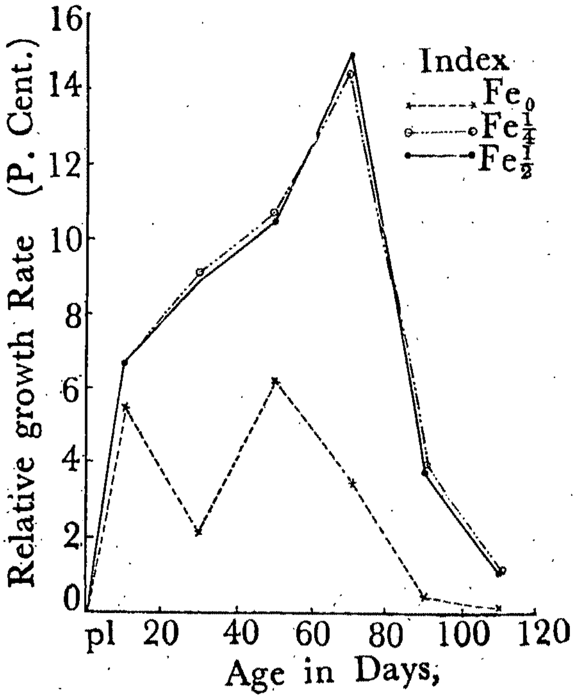

Fig. 3. Relative growth rate (per cent) as influenced by the concentrations of iron supplied throughout the life cycle.

nutrient iron, irrespective af the concentrations, exerted its significant influence during the period of maximum growth.

DISCUSSION

Gericke (1) workng on wheat and Aiyer (7) on rice have stressed that iron exerted its influence so long as the plant was gaining in weight. Gericke (1) also indicated that premature death occurs if the plants are deprived of iron beyond 4 to 6 weeks of life cycle. He, further, pointed out that deprivation after 8 to 10 weeks inhibits grain production but not the dry matter of vegetative parts. In the present investigation plants without iron have shown some growth, although, the lowest among the treatments (Table I). This must be attributed to the traces of iron that the sprouting embryo must have absorbed from the endosperm before the latter was dissected out on 5th (1950-1) and 7th (1951-2 and 1952-3) days. The wheat plants have responded to iron upto 80 days of its life cycle only as regards their growth, and this period represents the stage of increasing dry matter. It is also indicated that deprivation of iron beyond 40 days seriously reduced the dry matter production (Table III). Thus, it is inferred that iron is needed by wheat plants between 40 and 80 days of their growth period and particularly that between 60 and 80 days (Fig. II and Fig. III) which constitutes the maximum growth period of the plant life. It was further observed that if the period of initial absence of iron supply was extended beyond 40 days growth was significantly reduced and after a period of 80 days of initial absence, supply of iron to cultures did not increase the growth at all. It may be due to the low capacity of plants to assimilate iron after this period of initial absence. Further, the effective dose of iron appeared to be low i. e. $Fe\frac{1}{4}$ (3.22 p. p.m.), a conclusion also reached by Aiyer (6) and Twyman (7), but supply of iron at its highest level Fe_2 (25.82 p.p.m.) did not prove effective or toxic. This fact is supported by Quellette (8) who found no iron toxicity even with 60 p.p.m. concentration of iron in nutrient solution.

Increase in the concentration of iron supply increased its absorption (Table II). Increasing the period of initial presence increased the iron content in plants (Table III), and increasing the period of initial absence decreased the iron content (Table IV) irrespective of levels. It was also observed that high iron content corresponded to increased dry matter production (Table III, 1952-3). Supply of lower concentration of iron did not increase its absorption. Twyman (7) working on oats and Quellette (8) on Soy Beans have found that higher concentration of iron in the medium increased its absorption and low iron concentration in the solution corresponded to low iron content in plants. This may be in the present investigation due to large quantity of iron precipitated in the body when it was supplied in higher concentration which ultimately increased the iron content without increasing the growth of plants. On the other hand plants supplied with lower concentration of iron absorbed less iron and this small quantity might have been available to produce good growth. Somers and Shive (9) are of opinion that iron by being precipitated within the tissues may become inactivated and therefore unavailable to metabolic processes of the plant. Just, how this oxidation is brought about which inactivates the ferrous iron into ferric state, has been studied by Shive (10). Thus, it is inferred that the supply of iron at lower concentration was beneficial. Variation in the growth and iron absorption in all the three seasons in one particular treatment may be largely due to the seasonal variations viz. temperature, humidity, length of day etc.

SUMMARY

The results of a 3-year experiment on the effect of iron on wheat growth have been presented.

Increase in the iron supply in the medium depressed the dry matter production but increased the iron content of plants. Presence of iron between 40 and 80 days and particularly between 60 and 80 days was essential. Continuing the supply of iron beyond 80 days was not markedly beneficial. Initial absence of iron in the medium beyond 40 days seriously reduced the dry matter and also the iron content and supply after 80 days of initial absence was not effective at all. $Fe_{\frac{1}{2}}$ (3.22 p.p.m.) concentration proved most effective in increasing the dry matter. No toxicity was observed by using Fe_2 (25.82 p.p.m.), and supply of $Fe_{\frac{1}{2}}$ (6.45 p.p.m.) concentration after an initial absence was found to be as effective as Fe_1 (12.91 p. m. p. m.) and also throughout the growth of plants.

ACKNOWLEDGEMENT

My thanks are due to my Professor Dr. N. K. Anant Rao under whose guidence the work was under progress.

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STUDIES IN THE FAMILY BURSERACEAE

I—FLORAL ANATOMY OF *Balsamodendron mukul* Hook.

By R. D. SHUKLA, M. Sc., *Department of Botany, Government College, Ajmer (India).*

INTRODUCTION

The family Burseraceae has received very little attention from morphologists. This is probably due to the difficulties in getting suitable material of the family which is restricted to tropics. Wiger (18) worked out the embryology in certain species and Saunders (14) described the floral anatomy of *Canarium nitidum*. Taxonomists are not in agreement about the systematic position of the family (see, Engler, 5; Hutchinson, 7; Rendle, 13; Wettstein, 17; Gundersen, 6; Lawrence, 8; etc.). Since *Balsamodendron mukul* occurrs locally, it was considered worthwhile to work out the vascular anatomy of its flower.

MATERIAL AND METHOD

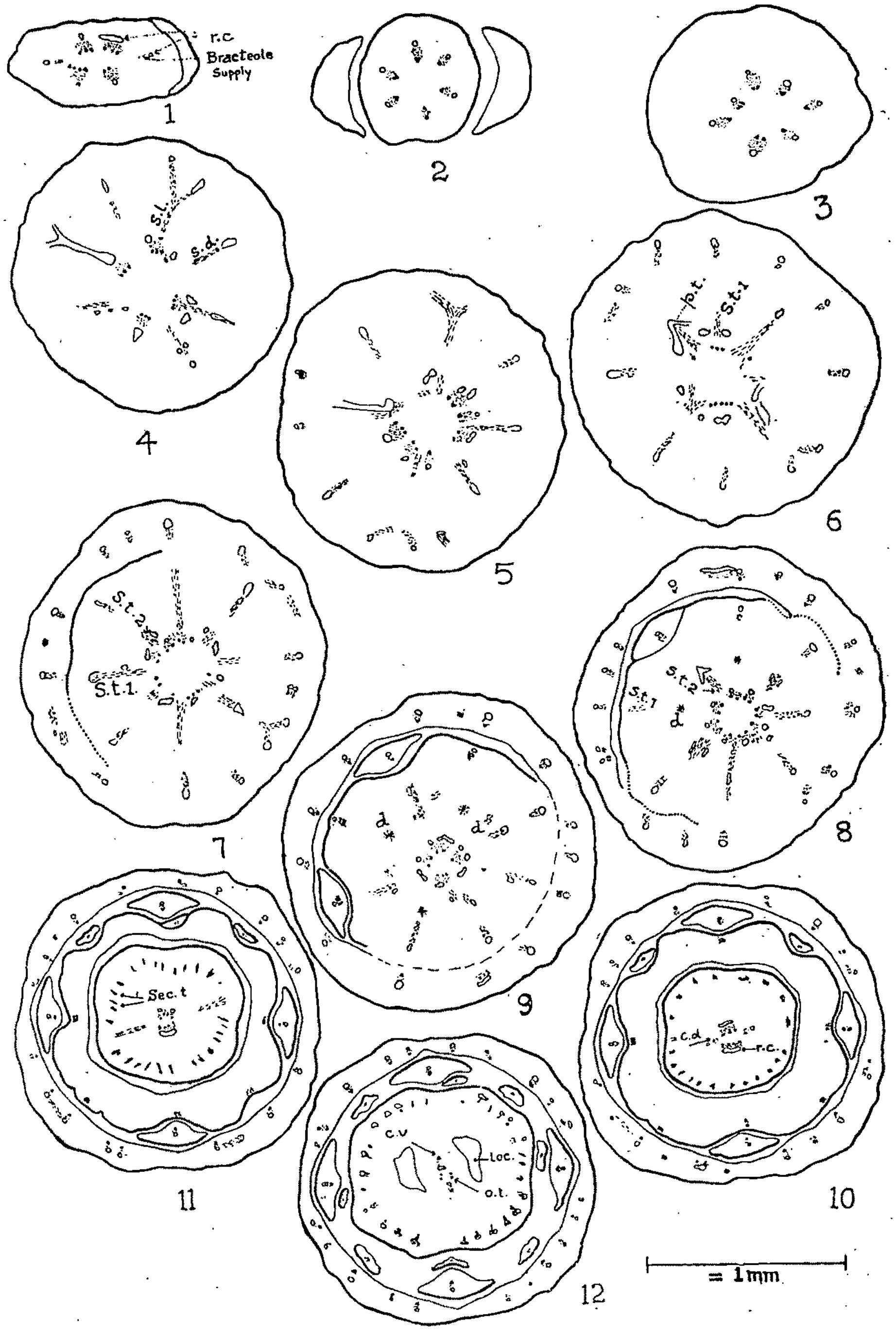
Open flowers and floral buds were fixed in formalin-acetic-alcohol. As the material was hard to cut, it was softened in 5-10% hydrofluoric acid for a week. Dehydration, clearing and embedding were carried out in the usual way. Serial sections, 12-15 micra thick, were cut at different stages of development, and stained with crystal violet and erythrosin.

EXTERNAL MORPHOLOGY

Balsamodendron is a small sized resinous tree with thick spreading branches ending in sharp spines. The bark is yellow, peeling off in thin papery pieces. Gum and resin exude from the wounds in the trunks. The leaves are tri-foliolate with lateral leaf-lets smaller than the terminal. The flowers are red, small, ebracteate, bracteolate and subsessile, borne in axillary clusters. The calyx is gamosepalous, four-toothed, cylinderical and is beset with glandular hairs. The four petals which are free and longer than the sepals are reflexed at the apex. Usually there are eight stamens, sometimes 9-10, borne in two whorls on the outer edge of the disc; those of the outer whorl are longer and antesepalous. The filaments have tangentially flattened bases. The anther develops normally up to the microspore mother cell stage which degenerate soon after in almost all cases observed (Shukla, 16). The ovary is sessile and is usually bilocular, rarely tri- and tetralocular. The loculi are opposite the lateral petals (Fig. 12) bearing two, rarely three ovules in the centre on axile placentae. The ovary tapers into a long and narrow style which ends in a capitate, glandular stigma. The fruit is a drupe.

FLORAL ANATOMY

The lower region of the flower shows six somewhat unequal vascular bundles, arranged in an antero-posterior symmetry. These bundles are typically



Figs. 1-12. *Balsamodendron mukul:* Serial cross section of the flower from base upwards, showing the vascular supply of bracteoles, sepals, petals, disc and the basal region of the ovary.

Fig. 1, traces for bracteoles diverging; Figs. 2-3, receptacle showing 6-7 vascular bundles, bracteoles non vascular. Figs. 4-5, traces for sepals diverging; Figs, 6-7 traces for petals and anteepalous stamens diverging; Fig. 8, antisepalous staminal traces dividing tangentially and the antepetalous staminal trace diverging; Fig. 9, antipetalous staminal traces dividing tangentially; Fig. 10, the stele flattended antero-posteriorly; Fig. 11, carpellary dorsals diverging; Fig. 12, the inverted ventral bundles of the carpels. c. d. carpellary dorsal; c. v. ventral bundles; d disc supply; loc. loculus; o. t. ovular traces; p. t. petal trace r. c. resin canal; sect. t. secretory tissue; s. t.-1. antesepalous staminal traces; s. t.-2. antipetalous staminal traces; S. L. Sepal lateral; S. d. Sepal dorsal.

The rest of the stele arranges itself in two somewhat arch-shaped strands in the antero-posterior position (Figs. 11, 13). From the free ends of these arches of vascular tissue one small bundle is given out on either side. These approach the corresponding branches of the other side and thus appear to complete the stelar cylinder once again (Fig. 14). The median branches in the meantime show split into two each (Fig. 14). These however, soon fuse together. In all, therefore, there are six to eight bundles forming the cylinder, out of these, two lateral bundles that lie very close together (Figs. 15, 16, o. t.) on either side pass out as ovular traces (Fig. 17).

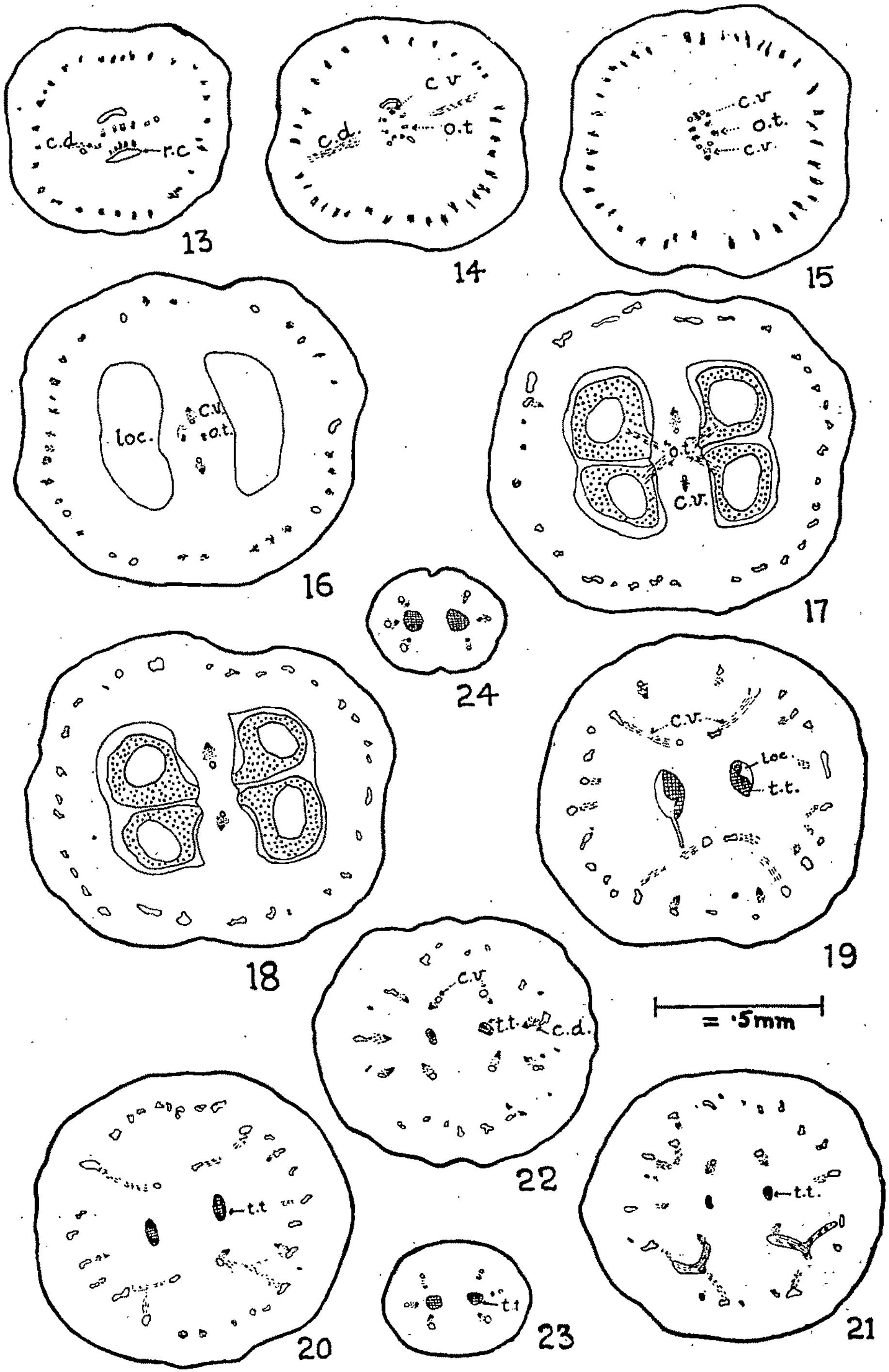
At the same time the median bundles which on each side consist of two branches, representing the ventral strands of the adjacent carpels, show fusion between their xylem elements. Simultaneously the resin canals split into two each and the xylem tissue migrates towards the outer side (Fig. 15). Soon afterwards, the two branches of the resin canals again fuse together, rendering the bundles inversely oriented (Fig. 16). These continue upto the base of the style, where each divides into two branches (Fig. 19). Each of these daughter branches gives out a small branch (Figs. 20, 21) which move towards the peripheral region of the ovary wall in which some tracheidal cells exist at certain places. In the upper region of the style and stigma there are six bundles arranged in two groups of three each, one dorsal and two ventral bundles (Figs. 22, 23). Associated with each of these groups is a small vertical column of transmitting tissue which originates at the base of the style (Fig. 19). The stigmatic region shows two prominent grooves antero-posteriorly (Fig. 24).

DISCUSSION

The foregoing account of the floral anatomy of *Balsamodendron mukul* reveals that the floral anatomy is that of a typical tetramerous flower. But there are some interesting points to which attention may be drawn here.

A study of the bracteoles reveals that sometimes they may have a rudimentary bundle but mostly they are without any vascular supply; the corresponding traces having disappeared in the cortex of the flower. Such an observation lends little support to the doctrine of conservatism of vascular tissue. Arber (1) has drawn attention to a number of cases of this type and she also has reached the same conclusion. Recently Puri (12) has dealt with the problem in some detail and has advocated that the doctorine should be given up.

It will be recalled that there are two whorls of four sometimes five stamens each. The vascular supply of the antesepalous stamens diverge earlier than



Figs. 13-24. *Balsamodendron mukul* ; Serial cross sections of the gynaeceum showing the course of the vascular bundles.

Fig. 13, stele flattened antero-posteriorly; Fig. 14, stele circular in outline; Fig. 15, ventral bundles in the process of inversion; Fig. 16, ovular traces in between the ventral bundles; Figs. 17-18, ovular traces passing into the ovules; Figs. 19-21, ventral bundles seperated and branched; Figs. 22-24, carpellary dorsals and ventral bundles have arranged in two groups of three each. Note the gradual disappearance of the tracheidal and secretory tissues.

c. d. carpellary dorsals; c. v. ventrals of the carpets; o. t. ovular traces; t. t. transmitting tissue, sect. t. secretory tissue; loc. loculus.

those of the antepetalous stamens. The stamens in *Balsamodendron mukul*, therefore, are not obdiplostemonous as is reported to be the condition in some other members of the Burseraceae (14).

It has already been described that the disc supply consists of four sometimes eight small bundles. These bundles arise as small branches from the diverging staminal traces. From this appears that the disc may be staminal in nature. Similar conditions have also been reported by Dawson (3) in *Cantua* and *Cobaea* and by Moore (9) in Rutaceae.

The vascular supply of the ovules deserve some special attention here. The small lateral bundles of the central cylinder that supply ovular traces are detached from the median bundles prior to their becoming inversely oriented (c. f. Fig. 14). This observation seems to go against Arber's (1) contention that the inversion of the ventrals or the placental strands is brought about by peculiar mode of bundle branching. Referring to *Papaver rhoeas* she writes, "the occurrence of 'inverted' bundles in the placentae is only one of the aberrant results that may follow when one collateral bundle has to supply a vascular system for a structure internal to itself on the same radius of the shoot." Apparently in *Balsamodendron mukul* branching has little to do with the inverse orientation of the ventral or placental strands.

The position of the ovules in the centre and the bilocular condition of the ovary indicates that the placentation in *Balsamodendron mukul* is axile. But it is not typically axile for the ventral strands occur on alternating radii with those of the dorsals of the carpels. The anatomy therefore, is that of a parietal placentation (12). The inversion of these bundles may be explained in some such manner as envisaged by Puri (10). Wiger (18) who made an extensive study of the embryology in this family has described the placentation as "central and marginal." As already pointed by Puri (12) such terms are unsatisfactory and confusing.

ACKNOWLEDGMENT

I am indebted to my teacher, Prof. B. Tiagi for suggesting the problem and for keen interest taken by him throughout the progress of this work; also to Prof. Dr. V. Puri, (School of Plant Morphology) Meerut College, Meerut, for facilities and valuable guidance. Thanks are also due to Principal V. V. John and to the Government of Ajmer State for encouragement and the award of a research scholarship.

SUMMARY

External morphology and floral anatomy of *Balsamodendron mukul* has been described.

The bracteoles are devoid of vascular supply, as their traces fade away in the receptacular cortex. The sepals receive three traces each, whereas the petals and stamens get one trace each.

The floral anatomy in this genus does not lend any support for the reported obdiplostemony in some other members of the family; the disc is interpretated as staminal in nature.

The placentation is axile; though not typically so, for its anatomy is that of a parietal placentation.

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PHYSIOLOGIC SPECIALIZATION IN *PUCCINIA PENNISETI* ZIMM. ON *PENNISETUM TYPHOIDES* STAPF. & HUBB.

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Introduction

The rust disease of *bajra* (*Pennisetum typhoides* Stapf & Hubb.) caused by *Puccinia penniseti* Zimm. is commonly found in East Africa and India. It was reproted by Zimmerman (1904) from Amman, East Africa, where the rust attacks both the leaves and the culms. In India, Butler (2) recorded the disease from several parts of the country particularly from South India where the rust is more prevalent. Ramakrishnan and Soumini (3) contributed to the life-history of the fungus reporting the occurrence of aecidial stage on *Solanum melongena* Linn. Basu Chaudhary (1) investigated the effect of temperature on the survival of the rust. Little is known about the possible measures of controlling the disease. In the light of the experience of the problem in other rusts it was considered worth while to investigate if there is any physiologic specialization in the *bajra* rust in the hope of the possibility of introducing improved varieties resistant to the disease. *Bajra* being a cross-pollinated crop the problem of breeding for disease resistance is very complicated. But due to the fact that within a particular area a variety may be a stable 'ecotype' the possibility of selecting improved varieties may not be very remote. However, before any attempt is made for the selection it is essential to investigate whether the rust shows any physiologic specialization. It is with this view that the present preliminary investigation has been carried out.

Material and Method

Rust samples were collected from local fields near about Agra, and also obtained from Kanpur, Nagpur and Coimbatore through the kindness of the State Mycologists. Stock cultures of the rusts were maintained on Agra Local variety which proved to be highly susceptible to all the four rust samples.

Twenty varieties of bajra were obtained from several parts of the country. Seedlings of each variety were raised in 6″ pots in a seedling house, each pot containing nine seedlings. When the seedlings were ten days old, the pots were transferred under aseptic conditions to the glass house. The pots were placed in a tray containing water and covered with a glass chamber for 24 hours, after which the leaves were finely sprayed with water and inoculated with rust by the help of a blunt lancet needle. The inoculated seedlings were again kept in the moist chamber for another 24 hours and then transferred to muslin partitioned compartments on the table tops of the glass house. The compartments were separated with double muslin curtains sprayed with water. Enough sunlight was admitted to the compartments through glass panes on one side. Care was taken that the rusts from different parts of the country were always kept separate from each other. The rust reaction was observed on the twelfth day after inoculation.

RESULTS

Since no reaction key is available for this rust, the common characteristic reactions recorded for other rusts have been employed in these experiments for the detection of any specialization in infection. So far all the bajra varieties tested were found to be susceptible to the rust samples. But distinct differences in infection types were noticed as shown in Table I.

(Note: For explanation to numbers, see Appendix 1).

As seen from the Table I, there is some indication of differences in rust reaction types as shown by the number of pustules, the intervening distance of pustules, necrosis and chlorosis of the host. Thus the samples of rust from the four localities do not appear to be quite similar with reference to nature of infection. But before any definite conclusions can be drawn with regard to physiologic races, experiments on more exhaustive scale have to be performed particularly with single spore cultures in order to ensure purity of race. It is intended to confine this kind of work to rust available in districts neighbouring Agra.

TABLE I. Rust Reaction on Varieties of Bajra in Seedling Stage.

Rust Sample.	No. of pustule		Distance		Necrosis		Chlorosis	
	Large	Few	Close	Scattered	Positive	Negative	Positive	Negative
AGRA	1,2,4,5, 6,10,12, 14,15,17, 19,20.	3,7,9, 11,18, 16.	2,4,6,8, 12,14, 15,16, 17,18, 19,20,	1,3,5,9 10,11.	9	Rest	2,6, 8,10, 12,14, 17,18.	Rest
KANPUR	2,3,7,11, 12,13,14, 15,18,19, 20.	1,4,5, 6,9,16, 17.	3,4,7,9, 10,11,12, 13,14,15, 16,17,18, 19,20.	1,2,5,6, 17.	1,16, 18.	Rest	1-20.	Nil
NAGPUR	2,3,8,10 11,12,13, 14,15,17, 18.	1,4,5,6, 7,9,16 20.	2,3,9,10, 11,12,13, 14,15,16, 17,18,20.	1,5,6,7, 8.	4.	1-3 5-20.	2,3,4, 5,7,9, 10,11, 12,13. 14,15, 16,20.	1,6,8, 12,18.
COIMBATORE	2,3,8,10 11,12,13, 14,15,17. 19,20.	1,4,5,6, 7,9,16, 18.	10,11,13, 14,15,16, 17,18,19, 20,3.	1,2,4,5, 6,7,8,9.	1,4.	Rest	Rest	5,8,9, 16, 17, 18, 19.

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The authors wish to offer their grateful thanks to the Secretary, U. P. Scientific Research Committee, Allahabad. Their sincere thanks are also due to State Mycologists and Economic Botanists of various States for supplying the rust samples and seeds of bajra varieties. The authors are specially indebted to Dr. R. S. Vasudeva, Head of the Division of Mycology and Plant Pathology, I. A. R. I., New Delhi and his Research Staff at Simla for the maintanance of some rust cultures during the summer.

SUMMARY

Twenty varieties of bajra from several parts of the country were tested in seedling stage to infection by samples of rusts and were found susceptible. The rust reaction types were noticed.

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APPENDIX 1.

Explanation to numbers used in Table I.

Bajra variety	Number indicated in the Table.
T5	1.
T 11/16	2.
T26	3.
T50	4.
T55	5.
BF 18	6.
BF 129	7.
BF 147	8.
BF 154	9.
CO 1	10.
CO 2	11
CO 3	12.
CO X2	13.
Piliv	14.
Valsong	15.
Arbhavi	16.

Local	17.
L. K. Sholapur	18.
L. K. Sajnuri	19.
Mandrup	20.

APPLICATION OF PHYSICO-CHEMICAL METHODS FOR STUDYING THE COMPOSITION OF INSOLUBLE METALLIC FERRO- AND FERRICYANIDES : A REVIEW OF THE RECENT WORK

PART II.—CONDUCTOMETRIC METHOD*

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INTRODUCTION

The earlier studies on the composition of metallic ferro- and ferricyanides (1) were done by analytical methods. In these methods several factors cannot be controlled: the precipitates are gelatinous and difficult to be washed free from impurities, easily pass into the colloidal state, adsorb ions during precipitation, undergo change due to hydrolysis etc. Thus, it is not surprising that by this method, to a given compound, different compositions have been attributed by different workers obtaining the precipitate under different conditions. Wyrouboff (1), for example, found that under varied conditions, the precipitate of copper ferrocyanide corresponded to $Cu_2Fe(CN)_6$ and $K_2CuFe(CN)_6$. $K_4Fe(CN)_6$, while according to Williams (38) when potassium ferrocyanide was exactly precipitated by a cupric salt the composition of the precipitate was $K_4Cu_4[Fe(CN)_6]_3$; in presence of large excess of cupric salt $K_2Cu_9[Fe(CN)_6]_5$ and in large excess of potassium ferrocyanide $K_{10}Cu_7[Fe(CN)_6]_6$. As has later been shown by electrometric titrometry (13,28) these are not true complexes but adsorption compounds formed under different conditions of precipitation. Similar conflicting views have also been expressed in the case of other ferro- and ferricyanides (1). The suitabaility of physico-chemical methods for the study of the composition of these compounds cannot be over emphasised. Conductometric, potentiometric and thermometric methods (3) have generally been employed. More recently amperometric (polarographic) method (2) has also been employed. X-ray diffraction studies of several ferro- and ferricyanide gels have also been carried out and these have been of considerable help in distinguishing between the adsorption compounds and the true alkali metal ferro- and ferricyanides.

An attempt has been made to review the results of the application of different physico-chemical methods for studying the composition of insoluble ferro- and ferricyanides with a view to give a co-ordinated picture of the existing knowledge of their composition. In this article only the results of conductometric method of study has been reviewed (3).

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EXPERIMENTAL

For conductivity measurements (4) the usual wheatstone bridge arrangement has generally been employed. The titrations can be carried out by gradually adding the metal salt solution from a micro-burette to a given volume of the potassium ferro- or ferricyanide solution taken in the conductivity cell. The contents of the cell after each addition are thoroughly stirred, and the precipitate allowed to settle before measuring the conductance. This is carried out till 0.5 to 1 *ml.* of the titrating solution has been added in excess of the equivalence point. The observed conductance is corrected for the dilution effect (14) by multiplying it by the factor $(V+v)/V$, where 'V' is the volume of the solution originally taken and 'v' is the volume of the titrant added up to a given stage.

The solubilty of these precipitates is generally small and hence their contribution to the conductance of the solution low, so the initial part of the curve before the equivalence point is a sharp fall. After the equivalence point there is a sudden increase in conductivity due to addition of excess of the metal salt solution. In some cases, however, in the region of equivalence point when the common ion effect is small, the observed conductance is higher due to the slight solubility and also due to hydrolysis of the precipitate and so the curve has a slight curvature in this region. The correct and point may, however, still be determined by extrapolation of the two straight line portions. Bhattacharya *et al.* (6-12, 16-24) have carried out the titrations in 10% and 20% alcoholic medium and have shown that these effects are very much reduced and the observed equivalence point then are closer to the calculated titres. In aquo-alchoholic medium the overall conductance of the solution is, however, smaller due to suppression of ionization of the reactants but the break in the curve is sharp. Typical curve for the titration of 0.0196 M-$K_4Fe(CN)_6$ by 0.1852 M-$CdS0_4$ in aqueous and 10 and 20 per cent alcoholic media are shown in Fig. 1. The titrations may also be carried out in the reverse way, i.e., by adding potassium ferro or ferricyanide solution from a micro burette to the metallic salt solution in the cell. Typical curve depicting the titration of 0.01.M-Ag NO_3 by 0.0197 M-$K_3Fe(CN)_6$ in aqueous, 10%, and 20% alchoholic media are shown in Fig. 2.

In both cases the composition of the precipitate can be computed from the volumes and the strengths of the reactant solutions.,

DISCUSSION OF RESULTS

Copper ferrocyanide: The composition has been studied by several workers. Kolthoff (28) found that in the titration of copper sulphate by potassium ferrocyanide first the normal salt $Cu_2Fe(CN)_6$ was percipitated which with further quantity of the reagent formed the double complex $K_2Cu_3[Fe(CN)_6]_2$ and followed by a third inflection corresponding to the formation of $K_4Cu_4[Fe(CN)_6]_3$. Britton and Dodd (13), however, obtained two breaks corres-

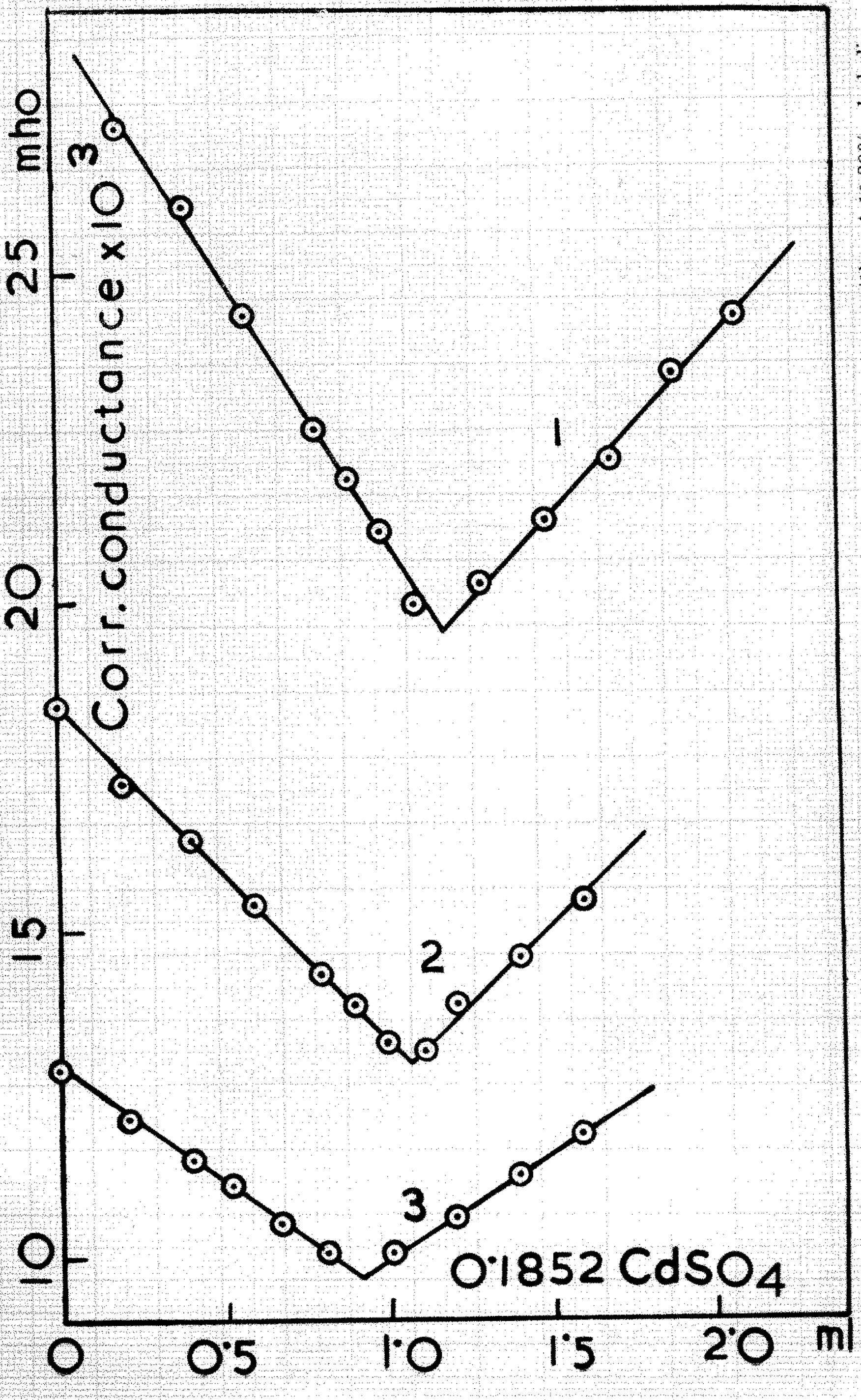

Fig. 1. Direct conductometric titration curve of .0196 MK_4 Fe $(CN)_6$ by 0.1852 M CdSo4 in aqueous (1) and 10,20% alcoholic media (2,3)

ponding to the formation of $Cu_2Fe(CN)_6.xK_4Fe(CN)_6$ where $x=0.16$ and 0.40. Ibaz and Feyto (26) also obtained two breaks in the conductometric titration of Cu^{++} by potassium ferrocyanide. Bhattacharya and Gaur (8) carried out the titrations by using potassium ferrocyanide as well as cupric sulphate as precipitant in aqueous and also aqueo-alcoholic medium. With potassium ferrocyanide as precipitant the composition of the precipitate at the equivalence point corresponded to the formation of $K_2Cu_3[Fe(CN)_6]_2$; the observed titres in 20% alcoholic medium were nearer the calculated one than in the aqueous medium. This has been confirmed by the potentiometric (7) and thermometric (6) methods. In the direct titrations (copper sulphate as precipitant) on the other hand a molecular mixture of $K_2CuFe(CN)_6.3K_2Cu_3(Fe(CN]_6]_2$ appears to be formed. This compound may, however, be regarded only as an adsorption compound; the strong adsorptive and hydrolytic nature of the precipitate (11) being responsible for it.

Thallium ferrocyanide: The composition was studied by Ripan and Popper (33). The precipitate is appreciably soluble in water and the compounds of varying composition were obtained, but within certain range the pure compound $Tl_4Fe(CN)_6$ was also formed. In presence of $Ca,^{++}$ however, the pure double ferrocyanide is perecipitated at all dilutions. The titration in presence of equivalent amount of Ca^{++} can be used for the estimation of thallium.

Lead ferrocyanide: Kolthoff (28), Britton and Dodd (13) and also Biemtz (32) have shown that the normal compound $Pb_2Fe(CN)_6$ is formed in the titration of Pb^{++} ions by ferrocyanide. This titration can also be used for the estimation of Pb^{++} or $Fe(CN)_6^{----}$.

Cadmium ferrocyanide: Bhattacharya and Gaur (10) carried out the titration of cadmium sulphate with potassium ferrocyanide and *vice versa* in aqueous medium as well as in presence of 20% alcoholic medium, and found that under the condition of the experiment only the compound $K_2CdFe(CN)_6$ was formed.

Uranyl ferrocyanide: The conductometric titration of uranyl nitrate with potassium ferrocyanide by Gaur, Gaur and Bhattacharya (24) revealed that the normal ferrocyanide is not formed but an adsorption compound of the composition $K_2(U0_2)Fe(CN)_6.x\ UO_2(NO_3)_2$, the value of x depending upon the concentration as also the order of mixing the reactants.

Mercury ferrocyanide: The formation of mercury ferrocyanide has been found by Gaur and Bhattacharya (23) to be quite complicated. There are number of peaks both in the direct and reverse titration curves. In the titration of ferrocyanide by acidified solution of mercuric nitrate the breaks correspond to the formation of the compounds of the type $K_2HgFe(CN)_6.\ xHg(NO_3)_2$ and also $Hg_2Fe(CN)_6.\ xHg(NO_3)_2$; while in the reverse titrations the compound formed are of the type $K_2HgFe\ (CN)_6.\ xK_4Fe(CN)_6$. However, the occurrence of a large number of peaks would need to be explained; adsorption alone cannot be responsible for this.

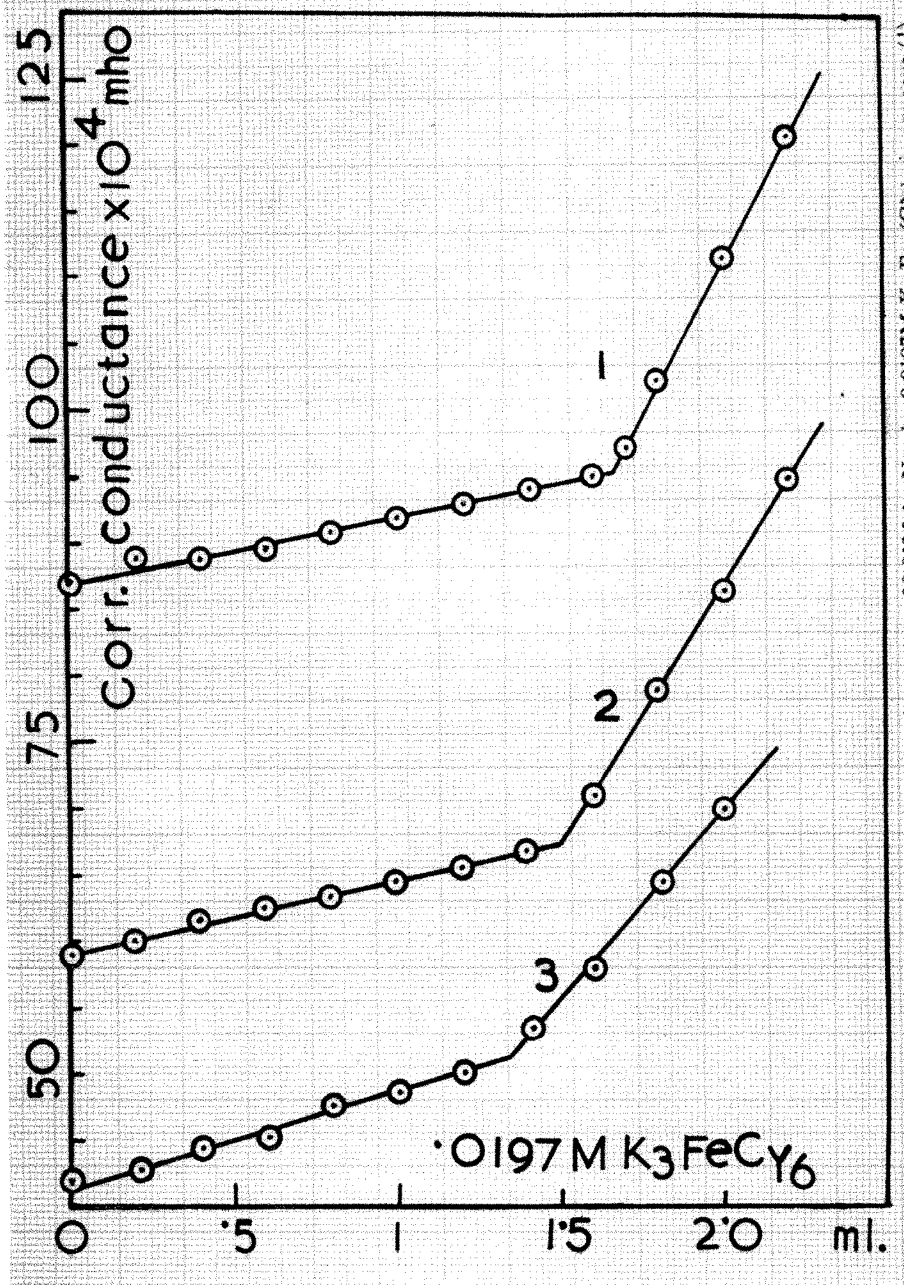

Fig. 2. Reverse conductometric titration curves of 0·01M Ag No$_3$ by 0·0197M K$_3$ Fe (CN)$_6$ in aqueous (1) and 10,20% alcoholic media (2,3).

Zinc ferrocyanide: Treadwell and Chervet (38) found that in the electrometric titration of zinc with potassium ferrocyanide or with sodium ferrocyanide in presence of K^+ ions, the end point corresponded to the formation of $K_2ZN_3[Fe(CN)_6]_2$; this titration can be used for the estimation of zinc (28).

Silver ferrocyanide: Britton and Dodd (13) found that in the conductometric titration of $AgNO_3$ with $K_4Fe(CN)_6$ the break corresponded to the formation of the compound $KAg_3Fe(CN)_6$. A rapid potentiometric titration showed an inflection at 2% more potassium ferrocyanide than was necessary for the formation of $Ag_4Fe(CN)_6$ (evidently due to the formation of little double salt). From this they concluded that two successive reactions (i) precipitation of $Ag_4Fe(CN)_6$ and (ii) its transformation into $KAg_3Fe(CN)_6$ according to:

$$3Ag_4Fe(CN)_6+K_4Fe(CN)_6=4KAg_3Fe(CN)_6$$

took place. Since (ii) is heterogenous, time would be needed and hence it is only when the reaction is carried out rapidly that the end point would correspond to the formation of $Ag_4Fe(CN)_6$. In a slow titration as conductometric, only $KAg_3Fe(CN)_6$ would be indicated.

Cobalt, Nickel, Manganese ferrocyanides: According to Kolthoff (28) in the titration of cobalt, nickel and manganese salts by potassium ferro-cyanide first the normal salt $M_2Fe(CN)_6$ is formed (M=Co, Ni, Mn) which is followed by a second break corresponding to the formation of $K_2M_3[Fe(CN)_6]_2$ and a third break corresponding to the composition of the type $[3K_4Fe(CN)_6+4MnFe(CN)_6]$. However, Briton and Dodd (13) regard that only the normal ferrocyanide is precipitated and the excess of potassium ferrocyanide is adsorbed by the compound; they represented these compounds by the formula $M_2Fe(CN)_6.x\ K_4Fe(CN)_6$, the value of x depending upon the metal and as the concentration of the reactants. This view has found support from the X-ray diffraction studies of the gels of these ferrocynides by Weiser, Milligan and Bates (40) in which they obtained distinctive X-radiograms corresponding to the formation of the compound of the type $M_2Fe(CN)_6$ only.

Thorium ferrocyanide: The composition of the compound has been found by Gaur and Bhattacharya (24) to be $ThFe(CN)_6$. It has been reported to be 'very stable compound of non-colloidal nature and is least affected by hydrolysis and adsorption.

Cerium ferrocyanide: The composition has been studied by Saxena (37) by the conductometric titrations between cerous nitrate and potassium ferrocyanide of different concentrations in aqueous and aquo-alcholic media. The compound $[KCe[Fe(CN)_6]$ was formed at the equivalence point.

Copper, Zinc and Cobalt ferricyanides: The composition copper (20), zinc (21) and cobalt (19) ferricyanides has been studied by Gaur and Bhattacharya, who carried out the titration of metal salt solutions with potassium ferricyanide by direct and reverse methods, in aqueous and aquo-alcholic media. The composition of the precipitate at the equivalence corresponded to the formation of the normal ferricyanide which may be represented by the general formula $M_3[Fe(CN)_6]_2$ where M stands for copper, zinc or cobalt.

Cadmium ferricyanide: The analytical study of the compound has been reported by Williams (39) and the composition arrived at is $KCd_{10}[Fe(CN)_6]_7$ with either reactant in excess. The conductometric studies of the composition of this compound have been carried out by Gaur and Bhattacharya (16) who confirmed that the composition of the precipitate at the equivalent point corresponded to $KCd_{10}[Fe(CN)_6]_7$. These conclusions have also been supported by the thermometric (17) study of its formation. From the electrometric studies alone it is difficult to say whether it is a true ferricyanide or only an adsorption compound. X-ray diffraction studies of the compound by Weiser *et. al.* (39) revealed the composition of the compound to correspond to $Cd_3[Fe(CN)_6]_2$. In view of this it appears that $KCd_{10}[Fe(CN_6)]_7$ is only an adsorption compound and may be regarded as $Cd_3[Fe(CN)_6]_2.0.7K_3Fe(CN)_6$. Later studies (18) have confirmed strong adsorptive nature of the compound.

Silver ferricyanide: In the precipitation of silver ferricyanide the precipitate at the equivalent joint has been found (28) to correspond to the formation $Ag_3Fe(CN)_6$. This titration can be used for the estimation of silver or ferricyanide.

Nickel and Manganese ferricyanides: The composition of nickel (22) and manganese (16) ferricyanide has been studied by Gaur and Bhattacharya. In the titration of the metal salt solution by potassium ferricyanide the composition of the precipitate at the equivalent point corresponds to the formation of $M_3[Fe(CN)_6]_2$ where M stands for Ni or Mn. However, when the metal salt solution is added to potassium ferricyanide the equivalent point is obtained a little too early and corresponding to the composition of the precipitate $KM_4[Fe(CN_6)]_3$.

Iron ferro-ferricyanides: Although the use of prussian blue has long been an important pigment, the chemistry of the compound, as of other iron cyanogen compounds, has not been satisfactorily explained till recently. The subject is surpisingly confused inspite of the voluminous work that has been published on it.

The common blue iron cyanides may be obtained by the interaction of Fe''' by $FeCy_{6-4}$ and Fe'' by $Fe''Cy_{6-3}$. However, it is no longer correct to say that the product of the first reaction is $Fe^{+3}_4[Fe^{+2}Cy_6]_3$, prussian blue, and of the latter $Fe^{+2}_3[FeC^{+3}y_6]_2$ the turnbull's blue, for on mixing either of them an oxidation-reduction equilibrium according to:

$$Fe^{+3} + FeCy_6^{-4} \rightleftharpoons Fe^{+2} + FeCy_6^{-3}$$

is set up before the precipitation occurs. This is disturbed by the formation of the precipitate, so that the composition of the precipitate would be determined by solubility relationships.

Analytical methods for investigation of the composition of these complexes were used by Hoffman (25), Mensner (29) etc. Their result were confirmed and later on extended by Müller (30) who showed that on adding increasing amount of $K_4Fe(CN)_6$ to $FeCl_3$ the following compounds were formed in order: $Fe'''_4[Fe''(CN)_6]_3$, $KFe''[Fe''(CN)_6]$ and $K_2Fe''[Fe''(CN)_3]$; while on adding the increasing amount of $K_3Fe(CN)_6$ to $FeCl_2$ the compounds $KFe''_2Fe'''_5[Fe''(CN)_6]_5$, $KFe'' Fe'''_3[Fe''(CN)_6]_3$, $KFe''' [Fe''(CN)_6]$ and $Fe'''_4 [Fe''CN)_6]_3$ were formed.

When the ratio of complex cyanide to iron was 1 : 1 the product was $KFe[Fe(CN)_6]$ in each case formed according to :

$$K_4Fe(CN)_6+FeCl_3=KFe[Fe(CN)_6]+3KCl$$
and
$$K_3Fe(CN)_6+FeCl_2=KFe[Fe(CN)_6]+2KCl$$

Although the work of Müller *et al.* has been very helpful in clarification of the confused ideas about the composition if iron cyanogen compounds, the compounds corresponding to the composition $KFe''Fe_5'''[Fe''(CN)_6]_5$ etc. should be regarded as adsorption complex rather than true alkali iron compound. In this case when the precipitate has strong adsorptive properties the analytical results also with direct or indirect analysis of the gel as a definite compound (5) must be accepted with caution.

The electrometric titration of (i) $FeCl_3$ with $K_4Fe(CN)_6$ and reverse and (ii) $FeCl_5$ with $K_3Fe(CN)_6$ in presence of 1 mole of KCl and reverse, were done by Müller and Lauterbach (31). All these curves cut at a point corresponding to the formation of $KFe[Fe (CN)_6]$ which was evidently formed in each case.

A systematic conductometric study of the precipitation of these compounds has been done by Bhattacharya and Saxena. In the case of prussian blue (12) they obtained two breaks in the conductivity curves which corresponded to the formation of the compounds $KFe [Fe(CN)_6]$ and $Fe_4[Fe(CN)_6]_3$ according to:

$$\text{(a)}\quad FeCl_3+K_4Fe(CN)=KFe[Fe(CN)_6]+3\ KCl$$
and
$$\text{(b)}\quad 4\ FeCl_3\quad 3K_3Fe(CN)_6=Fe_4'''[Fe(CN)_6]_3+12\ KCl$$

Since there is *a priori* formation of $KFe [Fe(CN)_6]$ in (a), in the present author's opinion it would be more appropriate to regard the formation of $Fe_4 Fe(CN)_6]_3$ by interaction of 1 molecule of $KFe [Fe (CN)_6]$ with 1/3 molecule of $FeCl_3$ according to:

$3KFe[Fe(CN)_6]+FeCl_3=Fe'''_4 [Fe''(CN)_6]_3+3\ KCl$ than as in (b). They did not obtain any other of the complexes obtained by Müller. In the titration of $K_3Fe(CN)$ by $FeCl_2$ (turnbull's blue) (34) there were two breaks corresponding to $KFe [Fe(CN)_6]$ and $Fe''_3[Fe(CN)_6]_2$ while in the precipitation of $K_4Fe(CN)_6$ by $FeCl_2$ (35) the two breaks corresponded to $K_2Fe''[Fe''(CN)_6]$ and $Fe''_2[Fe''(CN)_6]$. In all the three cases, in the reverse titrations there was only one break corresponding to the formation of the normal ferro or ferricyannide and no alkali iron compound was formed. In the case of Berlin green (36) (ferric ferricyanide)—an oxidation product of prussian blue, the precipitate at the equivalence point, in direct as well as reverse titrations, was $Fe'''[Fe'''(CN)_6]$. The formation of the above alkali iron compounds is in accord with the X-ray analysis of the precipitate by the powder method by Keggin and Miles (27) and, also with the X-ray diffraction studies of the gels by Weiser, Milligan and Bates (37).

The results obtained by other physico-chamical methods *vis-a-vis* the conductometric method will be discussed in another paper.

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FORMATIVE EFFECTS OF 2, 3, 5-TRI-IODOBENZOIC ACID ON *FOENICULUM VULGARE* MILL.

By S. N. CHATURVEDI, *Department of Botany, B. R. College, Agra.*

INTRODUCTION

A number of publications have appeared on the various formative effects of 2, 3, 5-triiodobenzoic acid (TIBA), an anti-auxin, on different plant organs. Zimmermann and Hitchocock (7) for the first time observed different formative effects like coalescence of leaves, production of abnormally large flowers, etc., in tomato plants treated with this chemical. Other workers (1, 6) have also observed a number of modifications in the vegetative parts in different plants when treated with TIBA. Gorter (2) and Wardlaw (6) observed ring-fasciated shoots with double vascular system, an interesting phenomenon which he considers to be of rare occurrence in nature.

One of the most interesting cases has been reported by Harder and Oppermann (3) in *Kalanchoe blossfeldiana* treated with TIBA solutions. According to them the terminal shoot generally ended in a cup-shaped formation and the first leaf also gave rise to similar structure. In a number of cases fresh branches came out through them.

Pillai and Chakravarti (4) reported various leaf deformities in *Brassica campestris* and *Lens esculenta.* In the former the leaves turn into ascidia-like structures and the petiolar portions develop into a cylindrical structure enclosing the shoot apices, which on their growth rupture it. In the latter plant there is a condensation of rachis and fusion of the leaflet margins giving the leaf a palmate appearance. Formation of ascidia and modification of individual leaflets into ascicular forms have also been reported by them in *Lens esculenta.*

The present communication deals with some of the formative effects of TIBA on the leaf, the inflorescence and the flower in *Foeniculum vulgare* Mill.

MATERIAL AND METHODS

The plants for the present investigation were grown in the Botanical Garden of B. R. College, Agra in a number of beds in which some plants were allowed to grow without any treatment, while others were treated with TIBA. The technique adopted was injecting the plants with 1 c.c. of TIBA solutions of different concentrations in the hollow stem by means of a syringe. TIBA applied in concentrations of 5000 p.p.m. produced various formative effects.

OBSERVATIONS

The deformities and modifications induced by this chemical are on the leaf, the inflorescence and the flower.

LEAF

Foeniculum vulgare has normally a pinnately de-compound leaf with a sheathing leaf base (Fig. 1 Plate). As a result of treatment there is a marked condensation of the midrib and the coalescence of the leaflets at their base giving the appearance of a much dissected fan-shaped structure (Fig. 2 Plate). The leaf sheath may remain normal at its lower region but its upper end becomes cylindrical as a result of closing up of the margins. This indicates a tendency towards ascidia formation.

In some cases the leaf sheath, which in a normal case is slightly concave, becomes completely closed forming a long cylindrical structure (Fig. 3 Plate). The leaflets also become fused near their bases forming a cup-shaped structure with dissected margins. There is thus a clear ascidia formation (Fig. 3, 9 Plate), as reported by earlier workers on some other plants (see Harder & Opopermann, 3; Pillai & Chakravarti, 4).

In such cases where the leaf sheath has become completely closed the axillary bud has to rupture it before coming out (Fig. 6 Plate).

INFLORESCENCE

In a normal plant the inflorescence is a compound umbel consisting of a number of umbellets (Fig. 4 Plate), each of which is provided with a long peduncle. In a treated plant there are marked changes in the structure of the inflorescence. The most important is the complete fusion of the umbellets (Fig. 6, 9 Plate). In the majority of cases the peduncles of all the umbellets fuse together to form a thick and a broad structure with a groove on one side (Fig. 7 Plate); thus changing the compound umbel more or less into a simple one where the flowers of all the umbellets seem to arise from this thick common structure. In some of these cases one or two umbellets do not fuse to form a common structure but remain free (Fig. 7, 8 Plate).

FLOWER

A number of flowers are generally borne on each umbellet (Fig. 5 Plate). The individual flowers are also affected by the treatment in the same way as the inflorescence. In the treated plants the most important change is the fusion of the pedicels of the flowers in groups of 2-4 (Fig. 12 Plate). The main portion of the flower may remain free but in extreme cases of adnation there is complete fusion of the flowers (Fig. 6, 8-11 Plate). This results in the formation of abnormally enlarged and deformed floral structures. These abnormal flowers do not grow further in size and their anatomical study which is in progress may throw further light on their arrested development.

The fusion of flowers and the umbellets is independent of each other as in some cases the flowers have completely fused while umbellets remained free (Fig. 11 Plate).

SUMMARY

The present investigation deals with the formative effects of TIBA, an anti-aumin, on *Foeniculum vulgare* Mill.

The plants injected with TIBA solution containing 5000 p. p. m. produced various formmative effects on the leaf, the inflorescence and the flower.

The leaf sheath in a treated plant becomes cylindrical and closed while there is a condensation of the midrib and the coalescence of leaflets giving rise to ascidia like structures. The axillary bud comes out rupturing the completely closed leaf sheath.

There are marked changes in the inflorescence of the treated plants. The compound umbel becomes converted into more or less a simple one due to the fusion of the peduncles of umbellets.

Abnormally enlarged and deformed floral structures are produced due to the fusion of the flowers in groups of 2-4.

ACKNOWLEDGMENTS

I am deeply indebted to Dr. S.C. Chakravarti for suggesting the problem and guidance during the course of investigation and to Prof. Bahadur Singh for valuable suggestions and criticism. The author also expresses his deep sense of gratitude to Dr. R. K. Singh, Principal, B. R. College, Agra for encouragement and facilities.

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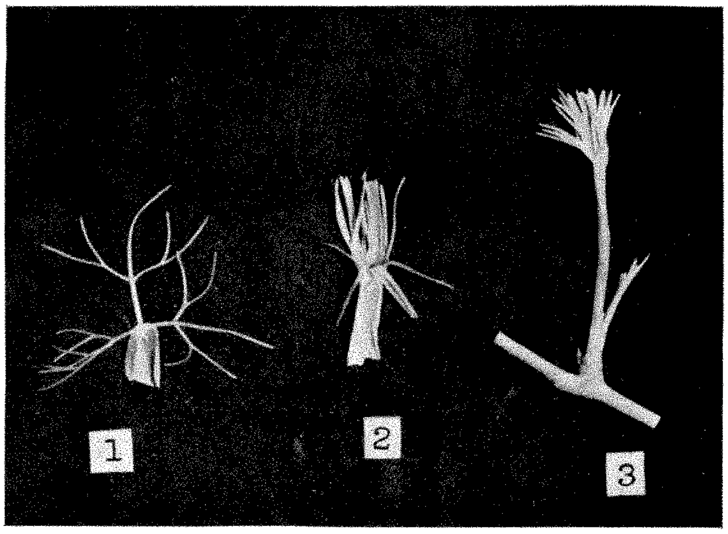


Fig. 1. A normal de-compound leaf of *Foeniculum vulgare* from an untreated plant.
Fig. 2. A leaf from a treated plant showing condensation of midrib and coalescence of leaflets
Fig. 3. Another leaf from a treated plant in which the leaf sheath has become completely closed forming a long cylindrical structure while the leaflets fused together to form a cup-shaped structure.

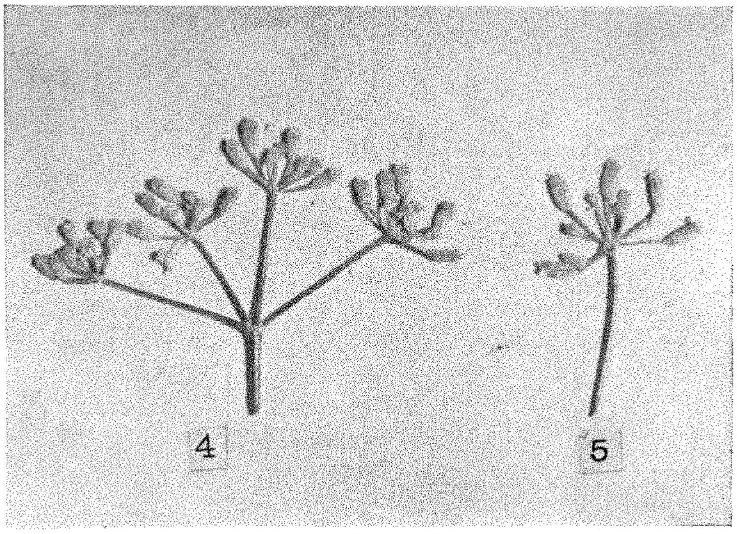
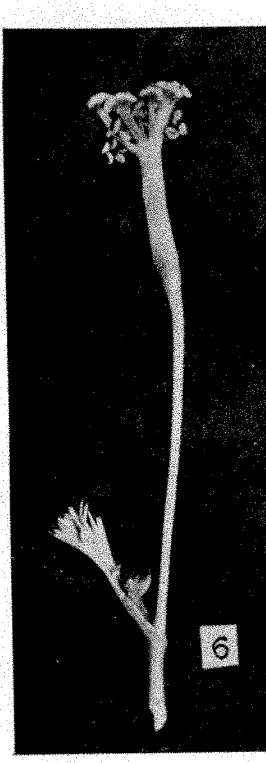


Fig. 4. Inflorescence (Compound umbel) from an untreated plant showing four distinct umbellets.
Fig. 5. An individual umbellet From 4.



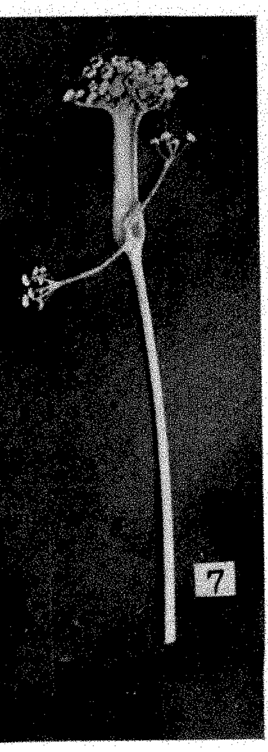


Fig. 6. Inflorescence from a treated plant showing the fusion of umbellets and flowers. Also showing in the lower region the emergence of axillary bud after rupturing the closed leaf sheath.

Fig. 7. Showing a groove on the fused portion of inflorescence of a treated plant in which two umbellets as well as flowers have remained free.

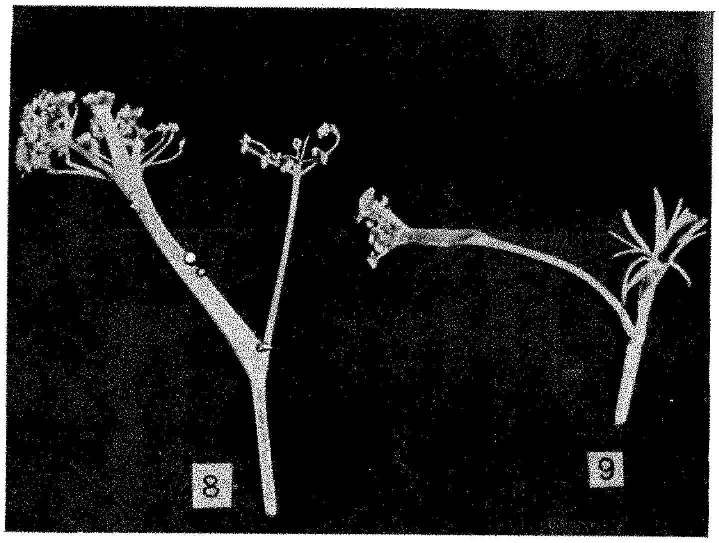


Fig. 8. Another inflorescence from a treated plant with fused umbellets and flowers leaving only one umbellet free.
Fig. 9. Showing a completely fused umbel and an ascidia shaped leaf.

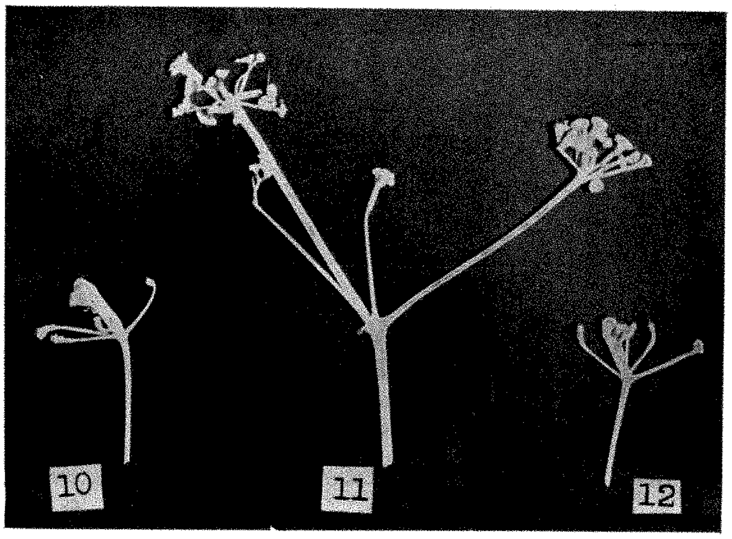


Fig. 10. An umbellet showing complete fusion of flowers.
Fig. 11. An umbel in which fusion of flowers has taken place while the umbellets are free.
Fig. 12. An umbellet showing partial fusion of some of the flowers.

COAGULATION OF COLLOIDS AND THE VARIATION OF TIME OF COAGULATION WITH ELECTROLYTE CONCENTRATION—A REVIEW OF THE RECENT WORK

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Introduction

The coagulation of colloids has been extensively studied by numerous eminent authors (Smoluchowski, Freundlich, Zsigmondy, Weiser, Kruyt Dhar, Ghosh, Mukherji, Joshi and others) and they have advanced various suggestions in this field to explain the intricate mechanism of rapid and slow coagulations. It was unquestionably established that colloidal solutions are biphased, hetero genous systems and that electrolytes coagulate them.

Smoluchowski (18) developed his memorable theory of the 'Kinetics of coagulation' on the assumption that the colloidal particles attract one another when the distance between them is smaller than a critical distance, R. The protective action of the double layer was supposed to be partly or completely destroyed by the adsorption of the electrolyte added. The probability of the particles to reach within the sphere of attraction of one another was calculated on the results of Brownian motion and the final shape given for the neutral particles was that the total number of particles at a time, 't' after the addition of electrolyte was $n = \frac{n_o}{1 + t/\theta}$ where $\theta = \frac{1}{4\pi DRn}$, D being the diffusion coefficient and n^o the initial number of freely moving primary particles. This equation was found to be in agreement with the rapid coagulation in which the particles are, a priori, completely or almost immediately deprived of their electrical properties by the addition of sufficient quantity of an electrolyte. But in the case of slow coagulation when smaller amounts of electrolyte are added the particles are not only under the influence of Brownian movement but are also under the repelling action of the residual charge. Hence in slow coagulation only such particles can adhere to each other, hence coalesce, as have sufficient kinetic energy to overcome the force of repulsion due to the charge on them. Hence, Smoluchowski met this condition by introducing a factor ε in his equation to represent the fraction of collisions that was effective to produce coalesence during slow coagulation and modified his original equation to $n = \frac{n_o}{1 + \varepsilon t/\theta}$ or $\frac{n_o}{n} = 1 + \frac{\varepsilon t}{\theta}$. Kruyt and van Arkel (10) tested this equation with gold and selenium sols and observed that the quantity θ/E was not constant for different intervals of time, while, according to Somluchowski, this factor should have been a constant. This showed that slow coagulation is a much more complicated phenomenon and Smoluchowski's ingenious equation failed miserably in the region of slow coagulation. On the other hand, Freundlich (6) made valuable contributions in the study of slow coagulation by measuring viscosity changes with time and gave a mathematical representation of the coagulation velocity by means of the differential equation $\frac{dx}{dt}=k(1+bx)(1-x)$ which, on integration gives $k=\frac{1}{t(1+b)}\log\frac{1+bx}{1-x}$ where x is the relative increase in coagulation at time 't' measured by the relative increase in the time of efflux; b and k are constants. Both Freundlich and Smoluchowski connected the stability of sols with the zeta potentials and recognised the fact that to start the coagulation the zeta potential of the particles must fall to a level known as the first critical potential. With increasing amounts of electrolytes, the zeta potential goes on decreasing to a second critical level where the particles reach the isoelectric point at which they are supposed to be almost completely neutralised. This state of the particles is characterised by their rapid coagulation, when the coagulation velocity is independent of the concentration and nature of the added electrolyte.

Verwey and Overbeek (19) made very important contributions to the problem of stability of colloids by making an exhaustive theoretical study of the structure of the double layer, its thermodynamics including the free energy. They further succeeded in making a thorough study of the interaction of the double layers and attractive forces of the colloidal particles.

Hamaker (8) has introduced a very useful method of getting a survey of the interaction between sol particles and thus of obtaining an expression of the stability of the corresponding sol. The method consists of drawing potential curves, representing the potential energy as a function of the distance between two colloidal particles. He also studied (9) the influence of the particle size on the physical behaviour of colloidal system.

Levine (12) calculated the interaction energy (potential energy) of two colloidal particles as a function of the distance between them by the application of the Debye-Huckel theory of strong electrolytes.

Levine and Dube (13) derived an expression for the calculation of interaction energy of spherical and charged particles in an aqueous electrolytic solution. They further applied (14) the potential energy curves and the theory of interaction between colloidal particles to determine the energy at contact (the energy maximum) to explain slow coagulation.

In short, reviewing the importance of the work of Verwey, Levine, Hamaker and others in the study of the stability of colloidal systems, we find that Freundlich and others laid great stress on zeta potential thus giving a partial solution because zeta potential is a function of only one colloidal micelle while coagulation is governed by the function of two or more micellae. On the other hand, Verwey, Levine, Hamaker and others conceived the variation of potential energy between two colloidal particles and this energy of interaction depends upon many other factors of which zeta potential is only one.

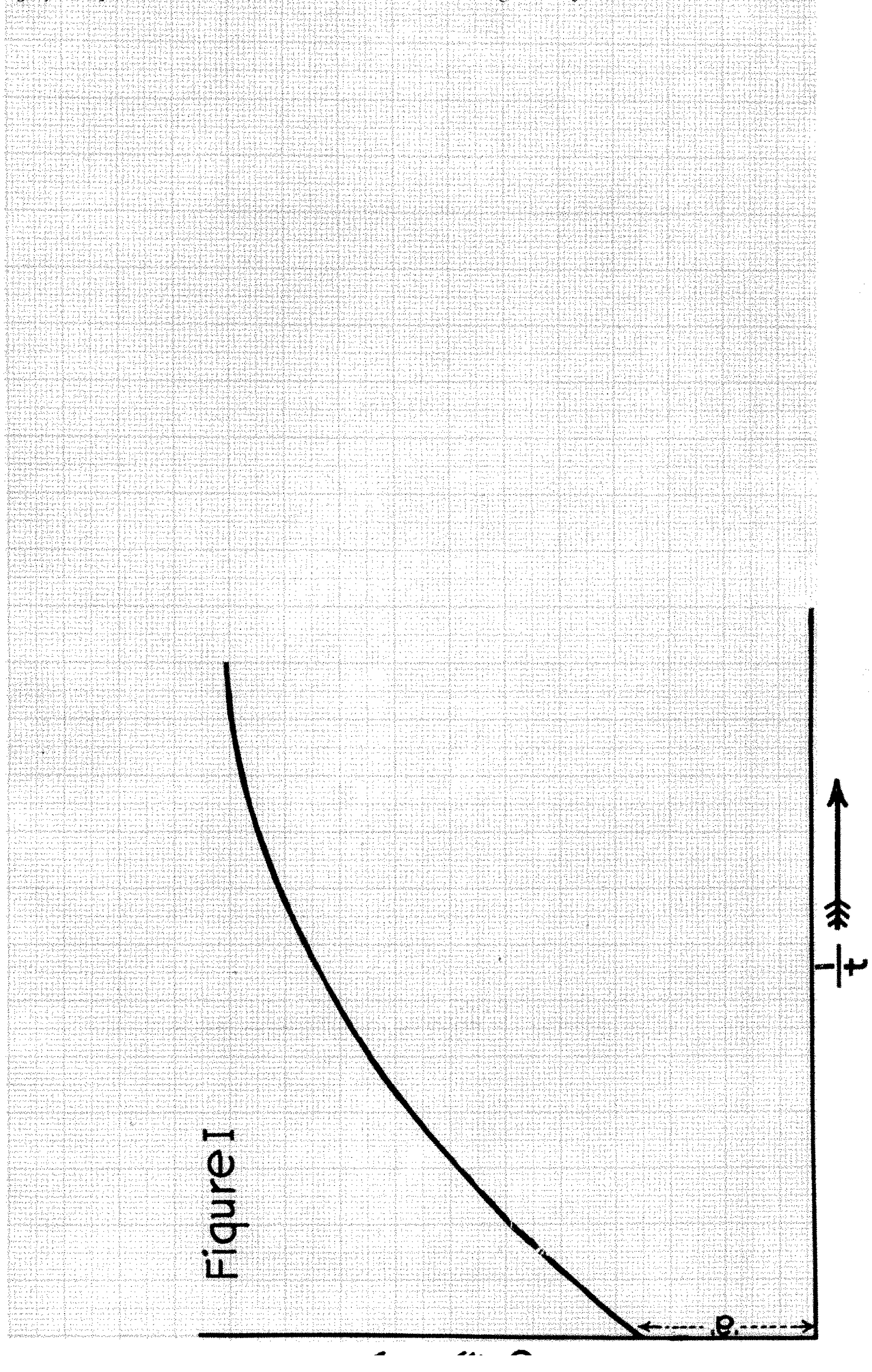

Figure I

Inspite of the extensive amount of work that has been done so far in order to elucidate the phenomenon of coagulation and the stability of colloids, it will be of much interest to review the attempts made to establish the important relationship between the concentration of the electrolyte and the time of coagulation. Mathews and Murphy (15), Boutaric (4), Dumanski and Scherschnev (5) investigated the relation between the electrolyte concentration and the staibility of sols. Their studies brought out the important fact that the time of coagulation was a function of the concentration of the electrolyte which, as expressed by Dumanski, was of the form $t=ac^n$, when 't' is time of coagulation and 'c' the number of c.c.' s of the electrolyte added, 'a' and 'n' being constants for the given system. Mathews and Murphy, and Boutaric also observed that for every electrolyte there is a limiting concentration below which coagulation was not possible.

Ram Kumar and Bhattacharya (1) reported the new equation to the slow coagulation of colloids, $C=a+\frac{m.1/t}{n+1/t}$ where 'C' is the concentration of the electrolyte, 't' is the time of coagulation, 'a', 'm' and 'n' are constants. The eqn. was tested by a number of sols including As_2S_3, Sb_2S_3, ferric hydroxide, chromium hydroxide, prussian blue, zinc ferrocyanide, copper ferrocyanide and silver.

Interpretation of the constants : a, m and n : When C and 1/t are plotted the curve cuts the C axis and the intercept at $1/t=0$ is given by 'a' i. e. 'a' is the value for $t \rightarrow \infty$. This means that the stability of the sol remains unaffected upto a concentration given by 'a' and it has been designated by Bhattacharya and Ram Kumar as the critical stability concentration of the electrolyte for the sol. When 1/t is very large compared to 'n' i. e. when 't' is very small as happens in the region of rapid coagulation, 'n' in the new equation can be neglected so that $C=a+m$ or $C\text{-}a=m$, or more strictly $C\text{-}a \rightarrow m$ in the rapid coagulation zone. Therefore 'm' represents the concentration of the electrolyte above the critical value 'a', which will produce instantaneous coagulation. In order to interpret 'n', an alternative form of the new equation, viz. $C\text{-}a=m/nt+1$ is considered. Working out the dimension of this equation, it is found that $nt+1$ should have no dimension and this can be only possible when n has the dimension T^{-1}. Hence 'n' was put as 1/t or k/t. Substituting $n=1/t$ in the new equation, C-a becomes equal to m/2; or if $n=k/t$ is substituted, $C\text{-}a=m/k+1$. This showed that 'n' is a characteristic constant of the sol which means that the sol will be coagulated in time interval 't' by $1/k+1$ the fraction of 'm' (quantity for instantaneous coagulation). Hence 'n' was connected with the sensitiveness and susceptibility of the sol to the electrolyte which becomes equal to k when $t=1$.

Determination of the constants a, m, and n:— The value of 'a' was determined from the intercept on the C axis of the C-1/t curves. Further the new equation can be written in the form $1/C\text{-}a=nt/m+1/m$. Hence by plotting 1/C-a against t, a straight line is obtained which cuts the 1/C-a axis to give '1/m'

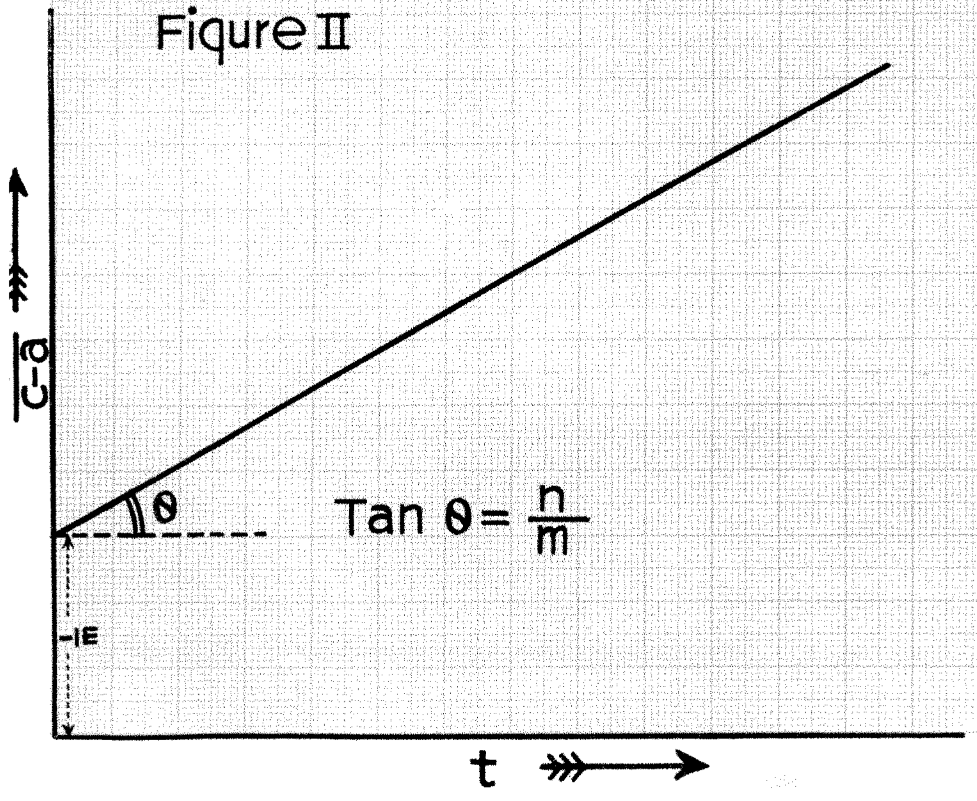

Figure II

and 'n' is obtained from the value of the tangent of the angle with the t-axis (vide figs. 1 and 2)

Relation between ϵ *and C* :—The relation between Smoluchowski's ϵ and concentration 'C' of the electrolyte was not known. An attempt has been made (3) to correlate the value of ϵ in terms of 'C' and the following form was given $\epsilon = \frac{k\,(C-a)}{k_1 - k_2(C-a)}$.

Verification of the New Equation $(C = a + \frac{m.1/t}{n+1/t})$ While studying the kinetics of slow coagulation of As_2S_3 sol by observing viscosity changes, it has been suggested in a recent communication (2) that the points of inflexion obtained in the viscosity-time curves denote the same kinetic state in the process of coagulation and the times corresponding to the inflexion points may be reasonably assumed to be such as to give the same stage of coagulation attained by adding different concentrations of the electrolyte. The reciprocal of the different times (1/t) corresponding to the points of inflexion were plotted against the respective concentrations (C) of the electrolyte used. The intercept obtained on the C-axis gave the value of the constant 'a' when $1/t = 0$. Knowing 'a', 1/C-a was plotted against 't' and the curve was found to be linear confirming the validity of the new equation. The new equation is further verified from the autocatalytic extinction-concentration curve of Kruyt and Troelstra (11) in the same way as has been done in the autocatalytic viscosity-time curves.

Very recently the new equation has been tested (20) by the data of previous eminent workers like Gann, Kruyt and Mukherji. During coagulation, if one observes the changes in physical property with time such as viscosity, absorption or scattering of light or extinction percent or the values of $\Sigma\frac{n}{n_0}$ by counting the number of particles, by adding different amounts of an electrolyte of concentration C_1, C_2, C_3, C_4 (say), curves ol characteristic nature are obtained The same stage of coagulation brought about by each concentration can be read from these curves by a line drawn parallel to the t-axis. The values of 't' with the concentrations C_1, C_2, C_3 and C_4 for the same stage of coagulation can be obtained from these curves. Then 'C' and '1/t' were plotted. The value of 'a' (critical stability concentration) was obtained as usual from the C-1/t curve. Then '1/C-a' was plotted against the time 't' for the same stage of coagulation. Straight lines were obtained in all cases showing the validity of the new equation from the data of Gann (viscosity) (7), Kruyt (light extinction) (11) and counting the no. of particles (10) Mukherji (light transmission) (16) and Schulz (tyndallometric) (17)

Grateful thanks are due to Professor A. K. Bhattacharya, D. Sc., F. R. I.C. Head of the Chemistry Department of Agra College for helpful suggestions and criticism.

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VASCULAR ANATOMY OF THE FLOWER OF *HIPTAGE BENGHALENSIS* (Linn) KURZ.*

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INTRODUCTION

The flower of Geraniales is commonly believed to have undergone considerable reduction, particularly in the androecium. Since *Malpighiaceae* is considered as the most highly evolved family in this order, it was expected that study of the vascular anatomy of the flower of *Hiptage benghalensis*, a beautiful garden shrub, will not be without interest. Besides, the calyx in this flower carries a large nectary, which also deserves some attention.

Young and old flower buds, collected from the botanical garden, Meerut College, fixed in F. A. A., were passed through grades of ethyl alcohol and xylol, and embedded in paraffin wax. Some material was also passed through grades of tertiary butyl alcohol, and embedded in paraffin wax. The latter treatment gave better results. Serial sections 10-14 μ thick were cut and stained in crystal violet and erythrosin.

OBSERVATIONS

External Morphology.—Hiptage benghalensis is a tropical climber, often cultivated in gardens for its beautiful and fragrant flowers. The flowers occur in axillary racemes, on jointed pedicels. They are bracteate pentamerous and zygomorphic. The two bracteoles arise at different levels, below the joint. The calyx is regular and consists of five free, persistent and leathery sepals, with imbricate aestivation. It bears a prominent nectary on the anterior side, which appears in the form of a triangular outgrowth. It extends from slightly below the base to about one half the length of the calyx, and is placed between two sepals. The nectary is devoid of any hairy covering. The petals are clawed and reflexed, with fimbriate margins. The anterior petal is slightly bigger than the other four. It has two hollow bulgings, one on either side of the limb, just above the claw. Petals being reflexed, the essential whorls are freely exposed in an open flower.

The androecium consists of ten stamens, in two whorls of five each. Of the outer stamens, which are antesepalous, the posterior one is the tallest and has the stoutest filament. The gynaeceum is tricarpellary. Each carpel has three outgrowths, on its outer surface; two lateral and one median, just below the style. The ovary wall is densely hairy. Of the three styles, two are short, and do not seem to have any receptive stigma. The style of the posterior carpel alone is rather long and recurved, bearing a simple receptive stigma at the top. The ovary is trilocular, with one ovule in each loculus, suspended from an axile placenta. The ovule is deeply curved.

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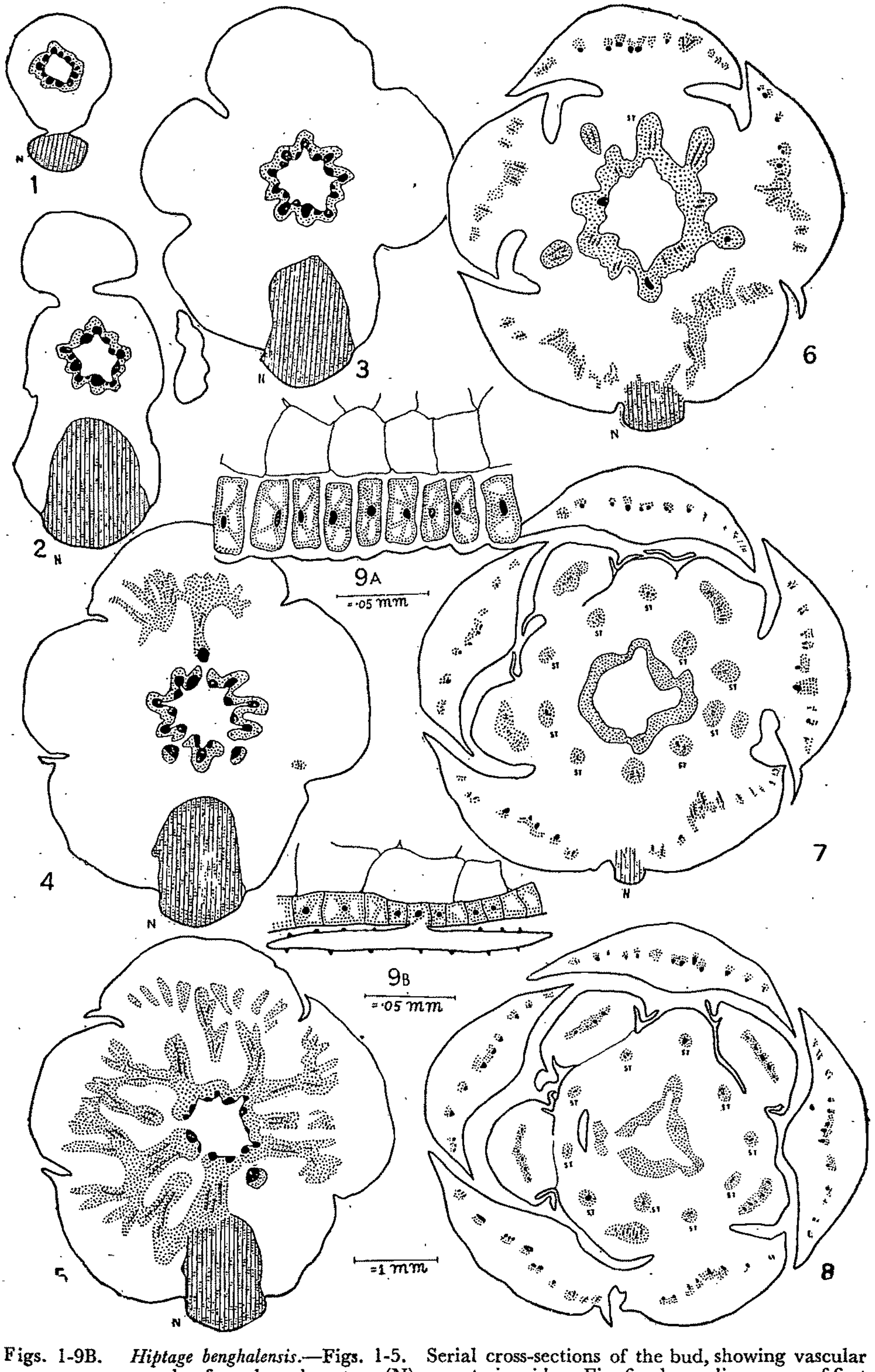


Figs. 1-9B. *Hiptage benghalensis.*—Figs. 1-5. Serial cross-sections of the bud, showing vascular supply of sepals and nectary (N) on anterior side. Fig. 6. shows divergence of first stamen trace (St)—posterior being antesepalous. Figs. 7-8. show divergence of other stamen traces and carpellary dorsals. Fig. 9 A. shows magnified view of a part of the glandular epidermis of the connective of a stamen. Fig. 9B. a magnified view of the' 'Malpighiaceous'' hair from sepal.

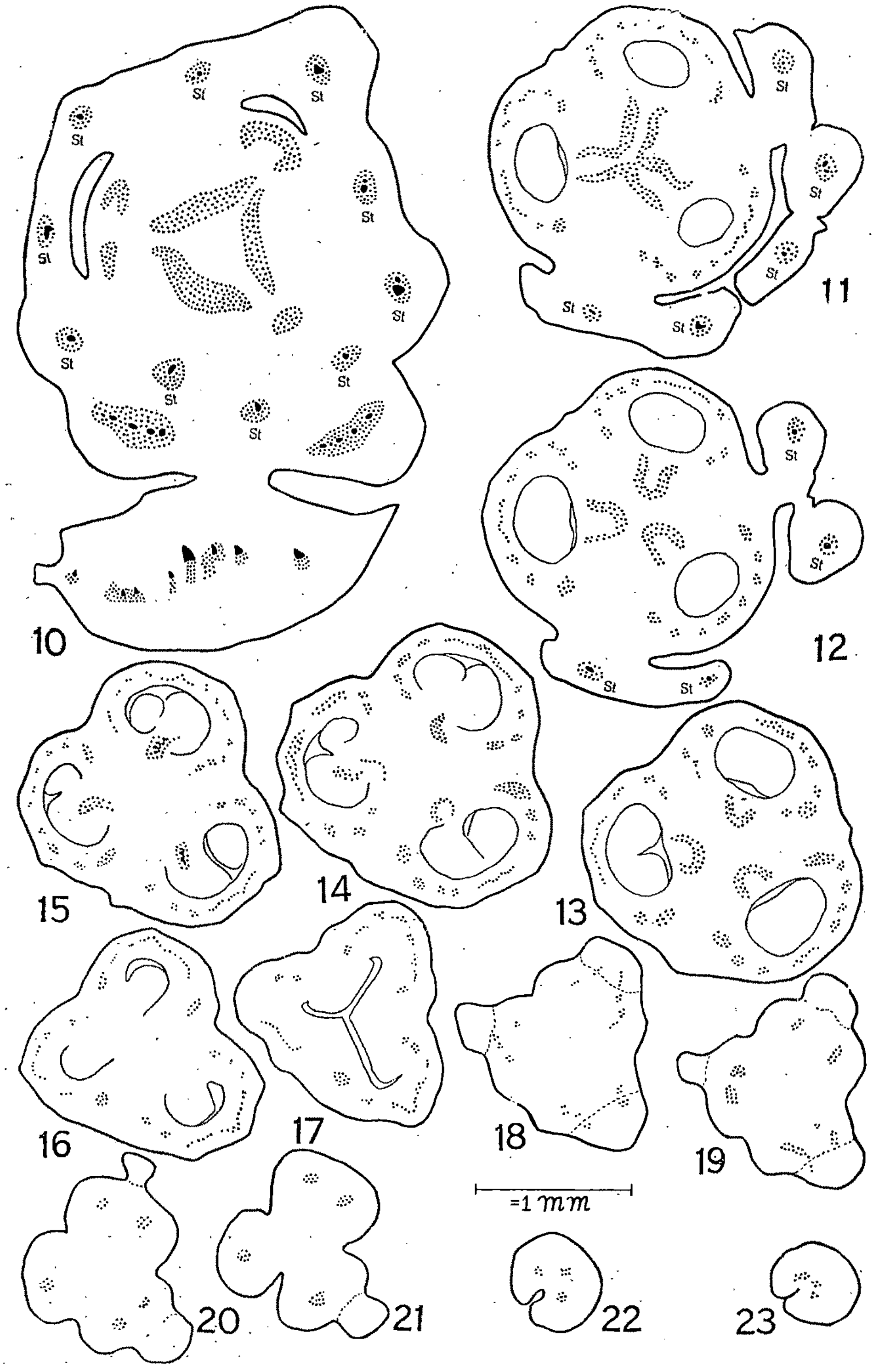
Vascular Anatomy.—The bract, the pedicel and the flower bud are covered with a dense coating of unicellular hairs, each of which has a very short stalk, and two long tapering arms, extending horizontally (Fig. 9 B). These are appressed to the surface and have tuberculated walls. Such hairs appear to be typical of the family Malpighiaceae (See Gundersen, 5; Metcalfe and Chalk, 6). The pedicel has densely staining epidermal cells, which appear to be glandular in nature. Cortex and pith also have a large number of deeply staining (with crystal violet) cells, scattered irregularly. Such secretory cells and those filled with tannin are reported to be common in parenchymatous tissue of stem and leaf also. (6).

The nectary is completely devoid of hairs. The columnar epidermal cells are highly glandular, a fact shown by their deep staining contents. They are markedly elongated anticlinally, the radial length being, approximately, five times the tangential length. The interior of the nectary is traversed by a large number of small groups of radially elongated cells, extending up to the hypodermal region. Some of the inner groups show the presence of spiral tracheids, which become more conspicuous by their increase in number towards the stelar side in the receptacular region. Similar groups of cells have been reported in *Salix* by Fisher (4) and they have been described as "suggestive tissue." In addition to these groups, the nectary has a large number of characteristic secretory cells, occurring singly, or in radial rows or in groups.

A transverse section of the pedicel shows a vascular cylinder of some 11-14 endarch collateral vascular bundles, which cannot always be clearly demarcated from one another (Fig. 1). In the receptacular region, the vascular cylinder appears more and more wavy in a cross-section (Figs. 2, 3 and 4).

The posterior sepal has a saccate base and is the first to appear (Fig. 2). Traces for sepals arise successively and irregularly. Each sepal receives three traces, one mid-rib and two laterals (Fig. 5). The laterals of adjacent sepals arise conjoint with petal traces (Fig. 5), and differentiate somewhat earlier than the sepal midrib bundles. The connection between the two laterals is seen before they get linked to the trace from the parent stele. So the trace, arising from the parent stele, bends downwards slightly, before bifurcating into the sepal laterals. Both the inner and outer epidermal layers of the sepals are glandular and covered with a hairy coating. The three traces of each sepal fuse and then give rise to a large number of branches. Secretory cells and tannin cells are scattered irregularly. The "suggestive tissue" of the nectary is mostly connected with the sepal laterals.

Each petal receives a single trace, which arises conjoint with the laterals of adjacent sepals (Fig. 6). The petal trace is concentric to begin with (Figs. 6 & 7) but higher up, it breaks up into a number of endarch bundles (Fig. 8). The main body of the petals is about 40-45 cells thick; whereas, it suddenly narrows to 5-6 cells in the margins. Secretory and tannin cells are irregularly



Figs. 10-23. Figs. 10-17 show the vascular supply of ovary wall and ovules. Figs. 18-23 show the vascular supply of the style.

scattered in petals also. Both the upper and the lower layers of epidermis are glandular, but hairs are present only on the abaxial side.

Although the stamens are, apparently, arranged in two whorls of five each, there is no such regularity in the mode of divergence of their traces. Each stamen receives a single trace, which is concentric. The first trace to separate from the parent stele is for posterior antesepalous stamen (Fig. 7). The second trace is also antesepalous, but the third, fourth, and fifth are antepetalous; sixth, seventh and eighth are antesepalous again, while ninth and tenth are antepetalous. Such an irregularity in the divergence of stamen traces is prevalent in the young buds also. Secretary and tannin filled cells are scattered in the parenchymatous tissue of the stamen. The epidermal cells of filament and connective, particularly the outer ones are glandular in nature (Fig. 9A). Filaments of two or three stamens separate from the receptacle collectively, before they separate from each other (Figs. 10, 11).

After the separation of stamen traces the parent stele becomes triangular in cross-section. From each angle, one trace diverges out and enters the corresponding carpel as its dorsal bundles (Fig. 8). This divides first into two (Fig. 10) and then into a number of branches which upward become indistinguishable from one another (Figs. 10, 11).

The remaining stelar tissue is arranged in the form of three bands in transverse section (Figs. 10, 11). These soon split into two each. Adjacent daughter branches of different pairs again fuse together on the dorsal radii forming U-shaped bundles (Figs. 12, 13). These are the ventral strands formed by the fusion of ventral bundles of the same carpel. Each ventral strand appears to pass into the single pendulous and deeply curved ovule of each carpel (Figs. 14, 15).

Each of the two lateral carpellary appendages, which become more prominent in the fruit, and hence not seen in the figures, receives a single branch from the lateral of the dorsal bundle. The apical appendage gets its vascular supply from the dorsal ridged part of the vascular bundle (Figs. 16, 17), which thus gets broken up into two lateral groups (Figs. 18, 19). These later pass into the style at a higher level (Figs. 19, 20). Epidermal cells of the ovary wall as well as the appendages have dense protoplasmic contents. They are covered with the characteristic unicellular hairs. Secretory cells and tannin cells are scattered in the ovary wall as well as in the ovule and central axis.

Every one of the three stylar protuberances receives two small vascular branches (Fig. 19). In the long and recurved style of the posterior carpel these branches break up into 5, 6, or 7 indistinct ramifications which appear to migrate toward the centre (Figs. 22, 23). In the short, non-receptive styles of the two lateral carpels the two bundles disappear one after another without further branching (Figs. 20, 21). Glandular hairs are also present in the lower region of the style, but they do not form so thick a coating, as in the ovary region below,

DISCUSSION

The laterals of two adjacent sepals and the trace for a petal are conjoint. The nectary receives the major portion of its vascular supply from the laterals of sepals and it is significant that it does not receive any vascular supply from the parent stele directly. The presence of vascular tissue in the nectary and its derivation from the sepal lateral seem to indicate that the nectary is calycine in nature.

The vascular supply of the sepals and petals is normal, but that of the stamens appears to be in contradiction to the common morphological description of the flower met with in systematic books. The order Geraniales, is commonly believed to be characterised by obdiplostemonous condition of the androceium but the flower of *Hiptage benghalensis* shows two whorls of stamens, alternating regularly with sepals and petals. It is interesting to note that staminal traces do not observe this alternation in the matter of their divergence from the parent stele. As pointed out earlier, the first two stamen traces to diverge are antesepalous, third fourth and fifth are antepetalous, sixth, seventh and eighth are antesepalous while ninth and tenth are antepetalous again. This irregularity in the origin of their traces, may be due to unequal toral growth on different sides of the receptacle, or it may have something to do with the obdiplostemonous condition reported in other members of the Geraniales (Dickson, 1936; Dawson, 1936).

Of the three carpels, forming the gynaeceum, it is only the posterior one which bears a long recurved style, while the other two have very short outgrowths only, without any receptive function. The fruit is the result of development of mostly the posterior carpel. Occasionally two or rarely all the three carpels may develop into fruit. Thus although gynaeceum is tricarpellary, it shows a tendency towards reduction, as seen by loss of styles in the two carpels and also in the number of carpels developing into fruit.

SUMMARY

1. The vascular anatomy of the flower of *Hiptage benghalensis* has been described. "Malpighiaceous" hairs cover pedicel, bracteoles, sepals, petals and ovary wall densely, but they are absent on the surface of nectary, whose epidermis is highly glandular. Secretory cells and tannin cells are abundant in parenchymatous tissue.

2. Sepal laterals and petal dorsals arise conjoint. Nectary receives most of its vascular supply from the laterals of the sepals.

3. Stamens are ten, in two whorls of five each, alternating regularly with sepals and petals. There is no regularity in the origin of their traces.

4. The gynaeceum shows specialization in so far as that two of its carpels do not possess receptive stigmas and that they occasionally fail to develop into fruit.

5. The entire ventral strand which is formed by the fusion of two ventrals belonging to the same carpel, is consumed in supplying the single ovule.

ACKNOWLEDGMENTS

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PROBLEMS OF PHOSPHATE MANURING IN INDIA

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The growing realization of the importance of phosphate in plant nutrition has led to a good deal of work and all the aspects of phosphate in relation to the growth of plants have been studied. Phosphate is absorbed by plants chiefly as orthophosphate ion and plays a fundamental role in enzymic reactions. It is a constituent of cell nucleus and is essential for cell division and for the development of meristem tissue. Its importance in plant growth is well known for its help in root growth and in fruiting and maturity.

Investigations in the last three decades in our country have shown that there is a universal deficiency of nitrogen and organic matter in Indian soils and in many tracts of our country nitrogen is a limiting factor in crop production. Phosphate deficiency is comparatively less widespread than that of nitrogen. Paddy soils adjoining Tanjore district are reported to be deficient in total and available P_2O_5 and a suitable phosphate manure is necessary for these soils (13). In the report of the Department of Agriculture, Madras for 1918-19 it has been stated that there is a crying need for phosphate for almost all crops. Howard (5) reported that available P_2O_5 in Pusa soils of Bihar is very less (0.001%) while Davis (3) has reported that the soils of Bihar are generally deficient in phosphate. Stewart (1947) has reported that phosphate deficiency is a factor of importance in many of the red and laterite soils of India. Agarwal (1) has indicated that semi-arid and northern Tarai areas of Uttar Pradesh are particularly lacking in soil phosphate. The Bundelkhand soils come next in order and the Central arid and North Eastern sub-humid soils are comparatively richer in this ingredient. The low state of soils fertility in our country was stressed in the report of the Royal Commission on Agriculture (1928) which states that soils of Madras, Mysore, South East Bombay, Hyderabad, Central Provinces (Now Madhya Pradesh), Orissa, and south Bengal are as a rule deficient in nitrogen, phosphoric acid and humus (Page 71). In regur soils (Black cotton soil) of India phosphoric acid, nitrogen and organic matter have been found to be generally deficient. The alluvial tracts of India which are agriculturally the most important tracts have been found to be deficient in phosphoric acid, nitrogen and organic matter. In all these types of soil potash and lime are generally sufficient.

Response of crops to the application of individual nutrients depends upon, the type of soil and its fertility level, the nature of the fertilizer and the crop. The moisture supply, pH and other physical and chemical properties of soil and also the environmental conditions. Response of crops to the application of nitrogen singly has been almost universal while positive response to phosphate has been reported only at few centres. There are instances where application of nitrogen and phosphate in combination to cereal crops has given better response than nitrogen and phosphate applied singly. Positive response to application of potash or in combination with other nutrients has been rare. In long term experiments F. Y. M. has shown as good yields of crop as given by fertilizers and has preserved the soils from deterioration. In short term experiments, the effect of F. Y. M. is slower than that of fertilizers but combination of F. Y. M. and nitrogenous fertilizer has shown the best result in such trials. This is also true for other bulky organic manures like compost. In the case of green manures beneficial results have been obtained in all cases where there has been sufficient moisture to ensure the decomposition of green matter.

Information pertaining to response of wheat, paddy, sugarcane, cotton, millets, oil seeds, pulses and green manure and fodder legume to phosphate fertilizers has been extracted from the summaries of the past experimental work by B. Vishwanath and Sethi (10), Rege (9), Panse *et al.* (8) and also from the report of the expert committee on manures and fetilizers appointed by the Government of India (1953) and other published work.

B. Vishawanath [1937, quoted by Diwan and Dutt, (4)] has surveyed the results of 257 carefully conducted manurial experiments in India from which an idea of the response of the crops to phosphate may be formed.

	Total No. of experiments	Exp. with sig. increase in yield %	Exp. with no sig. increase in yield %	Exp. with negative response %
F. Y. M. with or without artificial.	72	52	44	4
Green manure and phosphate	10	80	20	—
Bone meal	15	80	7	13
Phosphate	17	65	30	5
Nitrogen and phosphorus	51	70	26	4

The crops experimented were paddy, sugarcane, cotton, tobacco, maize, jowar, wheat and jute.

Wheat

(A) *Black soil tract* : (Bombay, Madhya Pradesh, Hyderabad, and Madhya Bharat) Phosphates do not appear to have been tried by themselves in any of the trials but several results with Niciphos and other mixtures of nitrogen and phosphates are available which illustrate the beneficial role of phosphate as a supplement to nitrogenous manuring of irrigated and unirrigated wheat. In the trials in which additional response to phosphate could be isolated it was calculated at 3.5 lb. per lb. of applied P_2O_5.

In two trials at Coimbatore superphosphate at 60 lbs. P_2O_5 gave an increase of 38-61%. NP was found to be better than N and P applied alone, ann NPK was better than NP.

(B) *Indo-Gangetic alluvium* : (Bihar, U. P. & Punjab) In the Bihar experiments response to phosphate alone was not consistent. It was only when phosphate was added as a supplement to nitrogen that a good response was secured. Superphosphate alone (40 lb./acre) has shown 90% increase in yield in Pusa manurial trials where a legume rotation is followed. NP combination (20 lb. N plus 40 lb. P_20_5) proved efficacious in Pusa. The increase in yield was about 130% over control. A combination of green manure (Sunnhemp) with super (80 lbs. P_20_5/acre) gave striking increase in yield of about 400% over control in Pusa trials for the past 16 years.

In U. P. response to phosphate or to combination of N and P were heterogeneous; there being appreciable positive as well as negative responses in different trials. Super at 18 lb. P_20_5/acre has given an increase of 15.6% over control at Aligarh (1911-21). The work done at different farms in U. P. (1939-42) indicates response with P_2O_5 was not obtained at any place except Kalyanpur (Kanpur) where during 1940-41, 15 lb. P_2O_5 gave better yields of wheat than no P_2O_5. Agarwal (1) has reported that application of nitrogenous and phosphatic fertilizers gave an increase in crop yields in Aligarh district. The use of phosphate alone is not suggested in view of nitrogen being a limiting factor in crop production in this State. The work done at B. R. College Experimental Farm, Bichpuri for the last 6 years indicates that application of phosphate at 20 lb. and 40 lb. P_2O_5 per acre produced significantly higher yield, with, however, non-significant differences between the two levels. Application at 81 b. and 16 lb. P_2O_5 per acre had no significant effect on yield. The author obtained a high response due to phosphate application in the newly acquired area of the Farm, the soils of which were deficient in P_2O_5 (0.005% available P_2O_5).

At Jullunder (Punjab) superphosphate at 125 lb. P_2O_5 gave 7.20% increase over no manure. At lower doses of 56 and 36 lb. P_2O_5 the responses have been in the order of 2.4 and 3.8 lb. grain per lb. of P_2O_5. Singh and Das (1945) have reported 29% increase in yield over control when phosphate was applied at 2.5 inches depth.

Paddy

Sethi (10), has reviewed the response of paddy crop to phosphate under Indian conditions. Though the phosphate requirement of paddy crop was indicated over large areas, it has failed to show any response at some places. Paddy has not responded to phosphate application at certain centres in India e.g., Nagina (U. P. 1930-37), and the Malabar Coast.

Superphosphate is not found to be suited for acidic soils of Assam, while bone meal has proved more beneficial. In the Khasi and Jaintia Hills bone meal applied at 25 lb. P_2O_5 /acre has given 75% increase of paddy over control;

(control was 2070 lb.). In West Bengal continuous application of bone meal over a period of 5 years has given significant increases (6.8 lb. per lb. of P_2O_5 at a dose of 60 lb. P_2O_5/acre). In Bihar (Gaya and Sabour), Orissa (Sambalpur, Barhampur and Jeypore), Madhya Pradesh (Chandkuri, Richhai, Raipur) and Madras (Manganallur) definite responses to phosphate have been obtained. At Sabour and Gaya a fairly high degree of response was obtained to NP manuring.

In Bombay superphosphate at 22 lb. P_2O_5 has given a response of 12.3 lb. paddy per lb. of P_2O_5 and with 22 lb. N as ammonium sulphate it has given 23 lb. paddy per lb. of N and P_2O_5 (Alibagh 1916-19). The work done in different parts of the country at various Research stations indicates that phosphate in combination with nitrogen and phosphate applied to green manure crops gave better response than N and P applied alone or only green manure crop.

Sugarcane

At Padegaon (Bombay 1936-39) superphosphate has shown definite superiority to bone meal. In NPK trials (1939-42) the effect of doses of phosphate in the first year was not significant while in the next two years it was significant with 50 lb. P_2O_5. In Bihar superphosphate alone has been rarely tried. In a trial at Gaya 54% increase in yield was obtained, i.e. 140 lb. cane per lb. of P_2O_5. In U.P. phosphates have not given any response at Shahjahanpur, Muzaffarnagar and Gorakhpur and no interaction between N and P was observed either. In earlier experiments at Pratapgarh (1918-22) superphosphate at 135 lb. P_2O_5 per acre has given an increase of 105% over control. The clayey Type II soil of Gorakhpur district shows a distinct need for both nitrogen and phosphorus and in this soil an increase in cane yield from 8.37% over control was obtained due to 40-80 lb. P_2O_5 per acre.

Cotton

Experiments in phosphate manuring of cotton appear to be very few. Superphosphate at Bellary (Madras) gave very little response at 55 lb. P_2O_5 but at Koilpatti (Madras) it gave 37% increase. Combination of N and P at 22 lb. N and 60 lb. P_2O_5 gave 63% increase over no manure. Superphosphate with green manure did not show any increase over green manure alone. At Aligarh (U. P.) green manure (sunnhemp or cowpea) with super (10 lb. P_20_5/acre) has given an increase of 105% over control. Bal (2) reviewing the work on cotton manuring has indicated that application of phosphate alone has given higher yields in M. P. (formerly C. P.) while in U. P. F. Y. M. and superphosphate were found to be effective.

Millets

Permanent manurial experiments at Coimbatore on irrigated *jowar* indicated little response to phosphate but the most outstanding result in these trials was the phenomenal increase obtained by a joint application of nitrogen and phosphate; phosphate is here the limiting factor controlling response to nitrogen. Phosphate alone had no effect on yield of *bajra*, but with ammonium sulphate or groundnut cake effect was marked on a basal dressing of F. Y. M. (Koilpatti Madras). Similar results were obtained for *ragi* at Coimbatore and also in Mysore in which the initial response to nitrogen was increased by the addition of phosphate.

Oil seeds

Groundnut responded uniformly to superphosphate applied at the rate of 30 to 40 lb. P_2O_5 per acre in M. P. and Bombay trials, the average response being 2.5 lbs. per lb. of P_2O_5. Response to combination of nitrogen and phosphorus was considerable in Bombay, M. P. and Madras trials. There was an indication also of the superiority of a higher proportion of phosphorus with nitrogen than in the ratio of 1:1. In four trials at Sepya, Jamuyi and Mongheyr there was an average increase of 10.0 lb. per lb. of P_2O_5 to an application of 30 lb. P_2O_5 per acre as superphosphate (Panse *et al.*, 8).

Pulses

Superphosphate increased the yield of *arahar* and *tur* at the rate of 7.0 and 9.4 lb. of P_2O_5 in Bihar for application of 16 and 32 lbs. of P_2O_5 but at two other stations there was no response (Panse *et al.*, 8).

Green manure and fodder legumes

Hope (Borbhetta, 1915) studied the relative efficiency of superphosphate, basic slag, ephosbasic phosphate and bones on the yield of green manure crops. Superphosphate and basic slag gave striking effects in increasing the growth of green crops.

Parr and Bose (Delhi, 1945) noted striking effects of phosphate fertilizers on berseem; superphosphate alone or in combination with organic manure produced a luxuriant growth in berseem and more than doubled the yield. Ammonium phosphate produced clear response in berseem with 88% increase over no manure. It was shown that berseem could in early stages make considerable use of ready supply of nitrogen whenever it was associated with available phosphate, but berseem could make no corresponding use of nitrogen when applied as sulphate of ammonia. The same action of phosphate (as superphosphate and ammonium phosphate) was brought about in regard to other winter legumes such as lucerne, senji, methi, peas and gram.

The work done by the author and other post-graduate students of Agronomy at B. R. College Experimental Farm Bichpuri, Agra, reveals that phosphate manuring of berseem offers a method not only of increasing the yield of legume crops and thus protein production but also of supplying Indian soils with the much needed addition of nitrogen for the benefit of crops such as wheat, barley, millets etc. which need large quantities of nitrogen for high yield.

From the above review it is clear that crop response to phosphate fertilizers varied greatly in different parts of the country. Rege and Sannabhadti, in dealing with phosphate manuring of sugarcane, emphasize the importance of soil type and the initial phosphate status of the soil, and show that, whereas nitrogen manures are necessary each year, continuous application of phosphate may not be necessary in view of the immobility in the soil and the relatively small extent to which it is removed in the crop. There are sufficient data for the immobility of phosphate in the soil, whereby phosphate fertilizers remain where they are placed and are not washed down to lower layers by rainfall or irrigation water. It has been noticed that even after several years, the phosphate was moved only to ½″ depth. In the past the immobility of phosphate seems to be little realized in our country as in many of the experiments conducted in this country at different centres phosphate was applied as top dressing in standing crop. This may be one of the reasons for the lack of crop response to phosphate fertilizers in many of the manurial experiments. In this regard it is worthwhile to quote Stewart (14) 'I was quite shocked to observe in the course of my tour that phosphate was being applied as top dressing to established crops in several government farms. There is abundant experimental evidence to show that phosphate is primarily of importance to root development in the plant and it follows from this that phosphate, in view of its immobility in the soil, should normally be applied and cultivated in, before the crop is sown.'

Phosphate is an element which encounters the greatest danger of becoming lost through combining or fixing influences of certain strong bases notably iron, aluminium, calcium and magnesium. In some alkaline soils the fixing power is so great that only small portion of added phosphate is available to plant for its assimilation. A number of factors influence the availability of phosphorus. Of these probably the most important are (i) Capacity of the soil to fix in an unavailable form, (ii) The amount of phosphate fertilizer applied, (iii) The kind of crops grown, and (iv) The method and time of application.

Small dressings of P_2O_5 are generally not beneficial on soils which are much deficient in phosphorus due to the fact that applied phosphate is absorbed by the soil rather than by the crop. Due to high fixing power of certain soils for phosphorus and the low recovery of this nutrient in the first application which amounts to about 10 to 20%, initial doses are to be made fairly large for satisfactory crop response.

To be effective on acid soils the phosphate dressing should be adequately buried. Active P_2O_5 should always be applied as shortly before the sowing as possible and should be applied to the root zone of the crop rather than surface application. The young roots from the germinating seedlings grow atonce into a narrow band rich in available phosphate and it is now well established that phosphate is of preeminent importance to crops specially cereals during the first few weeks. Localised placement of phosphate fertilizers ensures this high initial concentration without dissipating phosphates through an unnecessary large mass of soil. This has a second advantage in high calcareous and acid soils in which added soluble phosphate rapidly passes into very inert form. British farmers have recognised the value of drilling super-phosphate with the seed. In U. S. A. new fertilizer drills have been made to place the fertilizer in bands 2″ away and 1″ below the seed. A recent method followed in U. S. A. is to split the fertilizer in two parts; one part applied close to the seed and the other part 6″ deep in the soil to serve the need of the crop later. It is most efficient in drought and in areas where it readily combines with soil and potash to form unavailable compounds. Fertilizer can be mixed with the soil to the full depth of the cultivated layers by broadcasting before sowing. This system may have advantage for crops with a full root system and long growing season. In fine clay soils superphosphate is more efficient when placed in thin layer below the seed than when uniformly distributed throughout the soil.

Legumes need phosphate in large amounts regardless whether it is available in the soil or added as a fertilizer. This aspect of study should receive special attention in India where there is a universal deficiency of nitrogen in the soil. The importance of phosphate manuring of legumes as a means not only of increasing the yield and feeding quality of the leguminous crop as such but also of improving general soil fertility and thereby permitting of a far more efficient and intensive utilization of agricultural land especially under the condition of adequate irrigation has been demonstrated by Parr and Bose (1944-45) and it should not be lost sight of by the Indian agriculturist. There should be a common practice of applying phosphatic manures to legumes.

Recently, two new methods have been successfully tried at I. A. R. I., New Delhi, for increasing the availability of phosphate to plants and thus increasing the yield.

The first method, that of mixing superphosphate with about 20 to 50 times its weight of compost or F. Y. M. and applying the mixture to the field, permitted a greater return from the phosphates. The second method which proved still better is that of 'composting' the superphosphate with actively fermenting organic refuse. This is done by spreading the superphosphate powder in thin layers of about one-fourth inch thick over alternate layers of about six inches of mixed cattle-shed refuse or other compost material. The heap or trench so filled up is allowed to ferment for the usual period of five to six months after which the manure is well mixed and applied to the field. The compost ferments quicker and better if cattle urine or ammonium sulphate is added to the refuse. This method can also be used for composting rock phosphate and bone-meal, which contain insoluble phosphates. However, these fertilizers should be ground to a fine powder before composting them. At the I. A. R. I., four to six months after fermenting these fertilizers it was found that 50 to 70 per cent of the insoluble phosphates were converted into the more soluble forms which plants could absorb.

The other aspect of study may be the use of concentrated phosphatic fertilizer like sodium pyro and meta-phosphate which are used in large quantites in Tennesee Valley in U. S. A. Application of phosphate in granular form has also been advocated from several quarters for its efficient use. Soaking of seeds in molar and half molar solution should also form the basis of the study. Problems of phosphate manuring of cereals, specially the aspects of better utilization of phosphate fertilizers, are under study at the Balwant Rajput College Experimental Station, Bichpuri, Agra.

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HISTOCHEMICAL LOCALISATION AND MEASUREMENT OF ENZYME ACTIVITY IN CELLS BY PHOTO-ELECTRIC METHOD*

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TECHNIQUE

The chemical methods of localisation of enzymes histochemically gives only a qualitative distribution, but these methods cannot be applied for elucidating the enzymes quantitatively and hence comparative studies of these various tissues is very difficult. In the present studies a new technique, the details of which have been communicated and defined elsewhere (3), has been applied, by which the discharge of intake of dye fixed on a cell can be measured on a galvanometer with the help of a photocell attached to the microscope fitted with a side eye-piece for focussing the tissue. Light source is passed through the unstained

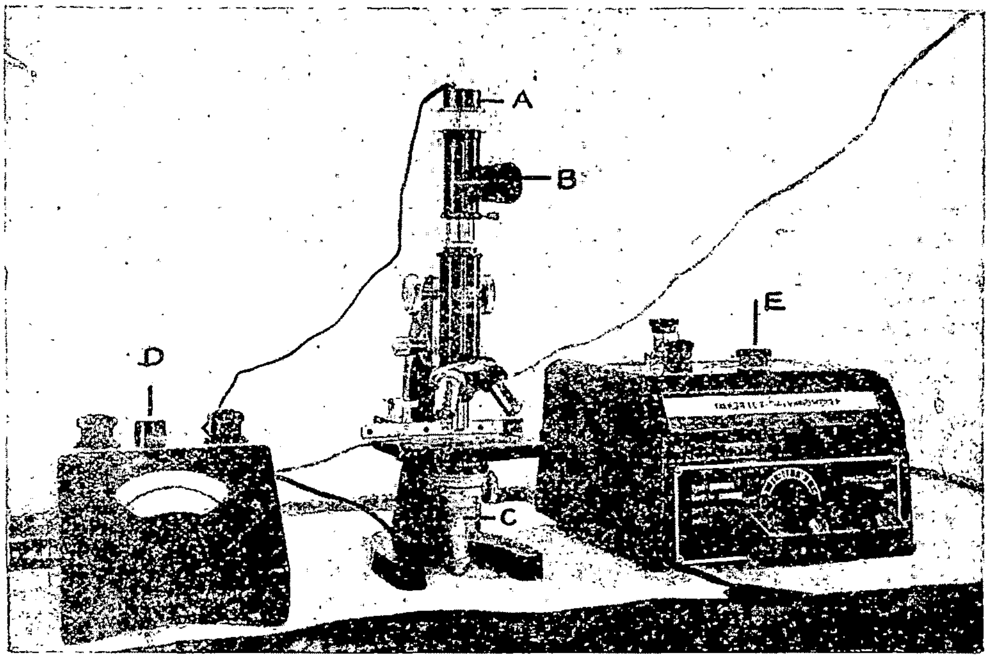

FIG. 1. Photograph showing the arrangement of the instrument.
A—Photo-cell in an encasement. B—Side Eye piece. C—Source of light. D—Galvanometer with percent transmission scale. E—Higher sensitivity galvanometer.

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specimen and the percent transmission is brought to the maximum by focussing the specimen by the side eye-piece and by adjustment of the distance of the light source,by the diaphragm of the condenser and also by the gross and fine resistances of the galvanometer. The specimen is then stained as desired and by focussing the same region of this stained specimen the percent transmission value which will now be much below that of the undyed or unstained specimen is recorded. From here percent transmission value the amount of light absorbed by the tissue or the rate of discharge of a particular dye fixed in the cell may be determined very accurately and this ultimately aids in measuring the activity of different enzymes which influence the production of coloured precipitate on the discharge of a particular dye in the various regions of the cell. The arrangement of the instrument is shown in the photograph.

EXPERIMENTAL PROCEDURE

With the help of above technique the activity of the enzymes like acid and alkaline phosphatase, phosphorylase and esterase synthesised during the process of germination of gram (*Cicer arietinum* L) has been assessed. In the present studies the tecnhique of section-cutting of the wax-embedded tissues was avoided because of its adverse effect on the activity due to temperature and other chemicals generally employed in this process. Fresh hand sections of 50 microns thickness were, however, used throughout the whole series of investigations.

The gram was germinated in a number of petri-dishes for a period of seven days. In order to avoid any contamination with extraneous compounds which might influence the actual synthesis of these enzymes the seeds were kept on ashless filter paper soaked with double distilled water in these petri-dishes. After each 24 hrs. germination one set of germinated seed was set apart and the radicles which come out in the meanwhile were quickly sectioned and the activity of the above enzymes in these sections were studied according to the methods detailed below.

ALKALINE AND ACID PHOSPHATASE

In the present procedure the phosphorus liberated from sodium β-glycerophosphate by the action of phosphatase, instead of being converted to cobalt phosphate and finally to insoluble cobalt sulphide as was followed by Gomori (4) was developed to blue colour by following the classical biochemical procedure of Bodansky (1) as used in the measurement of phosphatase in serum.

A number of sections of radicle were placed on a slide and the percent transmission of light due to these sections was brought to maximum according to the above procedure and the galvanometric scale reading thereby recorded. Same sections were then incubated in sodium β-glycerophosphate (2%) with appropriate buffer (acid buffer of pH 4.7 for acid phosphatase and alkaline buffer of pH 9.4 for alkaline phosphatase) for 2 hrs. at the end of which they were treated with 1 c.c. of 2.5% ammonium molybdate in dilute sulphuric acid and 1 c.c. of 0.5% amino naphthol sulphonic acid solution.

In another batch of similar sections the phosphatase activity was destroyed by addition of 30% trichloracetic acid for a few minutes and the blue colour developed due to the presence of free phosphorus was developed in similar manner and the percent transmission readings by these sections were also noted.

From the above percent transmission values of galvanometer scale, the amount of light absorbed by the different stained sections was calculated as below:—

If A —represents the initial maximum percent transmission value of blank specimen
B —represents the percent transmission value of enzyme killed specimen
C —represents the percent transmission value of enzyme preserved specimen
Then B—A represents the percent absorption of light due to free phosphorus in enzyme killed specimen
C—A represents the percent absorption of light due to total phosphorus of enzyme preserved specimen
And (C—A)- (B—A) i.e., C—B will represent the percent absorption of light due to phosphorus liberated by enzyme activity.

Whereas the values of the percent transmission will be inversely proportional to the depth of the colour, the values of percent absorption calculated in the above way will on the other hand maintain direct relationship.

In the table the first column under each enzyme represents the percent absorption of blue colour due to phosphorus in enzyme preserved section, second column the percent absorption of free phosphorus in enzyme killed specimen and the third represents the percent absorption due to phosphorus liberated only by enzyme.

PHOSPHORYLASE

In the literature only one method is reported (5) for the localization of phosphorylase in the cell structure and this is based on the colouration of starch synthesis by the action of this enzyme on glucose-1- phosphate in different regions of tissue with iodine and potassium iodide. The process is complicated because of the difficulty in removing the starch already present in the sections which if not removed properly will, however, hinder in judging the actual amount of starch which had been synthesised by the action of phosphorylase. In the present procedure the method which is generally used for biochemical study (2) i.e., by incubating with glucose-1- phosphate and measuring the liberated phosphorus by developing blue colour with ammonium molybdate and amino napthol sulphonic acid solution has been adopted and thus the complicated process of removing the initial starch has been avoided. Just in the same way as in case of phosphatases the maximum percent transmission of same blank sections (unincubated) are at first recorded. These sections were then incubated with glucose 1-phosphate and 1 c.c. citrate buffer of pH 6 and 5 c.c. of toluene for 30 minutes and blue colour was developed in liberated phosphorus in the same way as in case of phosphatases. The percent transmission of light due to these coloured sections were then recorded. Another batch of sections were similarly treated after destroying the enzyme by 30% trichloracetic acid and percent transmission due to these sections also recorded. From all these values the activity was then assessed just as in the same way as in the case of phosphatases.

ESTERASE

In the localisation of esterases no method has been reported in the literature. In the measurement of esterase activity by biochemical procedure two methods are generally adopted. One in which enzyme extract is incubated with a fatty ester at a certain pH and the amount of acid liberated during this period is titrated by 0.01 N. NaOH and the amount of NaOH required gives the measure of activity and the other in which the change of pH during a certain period of incubation of the enzyme extract with substrate fatty acid ester-gives the measure of enzyme activity. But none of these methods were found satisfactory for histochemical work. The following method has therefore, been developed which is based on the development of pink colour by a known amount of phenolphthalein and N/10 NaOH and noting the time required for discharge of this colour when incubated with enzyme and substrate.

A number of sections in the presence of substrate in the cavity slide are brought to focus and the maximum percent transmission against these sections are recorded. A similar number of sections were soaked in 1 c.c. of phenolphthalein and 0.5 c.c. of N/10 NaOH for 10 minutes. During this period a certain definite amount of NaOH gets access into the cells and be fixed there showing a definite tint of pink colour due to phenolphthalein. These sections were then transferred to ethyl butyrate in another series of cavity slides and the percent transmission of these dyed specimen were immediately recorded by properly focussing the same position of the specimen as in case of undyed section before. With the adjustment of time the butyric acid will be liberated by the action of esterase in cell and gradually the pink colour will fade until it is completely discharged. At this discharge point the percent transmission will attain the same value as in case of undyed section. The time required for this discharge of the phenolphthalein colour will give the measure of this activity. Since a definite amount of N/10 NaOH was fixed in each cell the time required to liberate the proportional amount of butyric acid to neutralise the above cell fixed NaOH will depend on the activity of the enzyme and the time of discharge of the phenolphthalein gives the measure of the comparative activity of this enzyme.

TABLE —I *Showing the Amount of Percent Absorption of Light due to the Blue Colour Developed By Liberated phosphorus with Ammonium Molybdate and Amino Sulphonic Acid and their Correlation with Activities of Alkaline and Acid Phosphatases and Phosphorylase in Radicle of Cicer arietinum during the period of Germination.*

Period of germination in hours.	*Alkaline Phosphates.* *Amount of p. c. absorption of light*			*Acid Phosphatase* *Amount of p. c. absorption of light*			*Phospnorylase* *Amount of p. c. absorption of light*		
	Enzyme preserved specimen	Enzyme killed specimen	Amt. due to enzymatic activity	Enzyme preserved specimen	Enzyme killed specimen	Amt. due to Enzymatic activity	Enzyme preserved specimen	Enzyme killed specimen	Amt. due to enzymatic activity
24	6.0	1.0	5.0	8.0	1.0	7.0	3.0	1.0	2.0
48	7.0	1.0	6.0	10.0	1.5	8.5	3.5	1.0	2.5
72	10.0	2.0	8.0	15.0	2.0	13.0	10.0	2.0	8.0
96	11.0	2.0	9.0	19.0	2.5	16.5	12.5	2.5	10.0
120	13.0	3.0	10.0	21.0	3.0	18.0	13.0	2.5	10.5
144	16.0	4.0	12.0	22.0	4.0	17.0	17.0	3.0	14.0
168	15.5	4.0	11.5	22.5	4.5	18.0	16.0	4.0	12.0

TABLE —II. *Showing the total time of discharge of Phenolphthalein colour and relative esterase of Radicle of Cicer arietinum for 7 consequtive days of germination.*

Period of germination in hours.	Time taken for decolourisation of phenolphihalein T.	Activity. $\frac{1}{T}$
24	16 min.	0.062
48	12 ”	0.083
72	10 ”	0.100
96	9 ”	0.111
120	8 ”	0.125
144	6.5 ”	0.153
168	6 ”	0.166

DISCUSSION

The amount of percent absorption due to un-incubated and incubated sections of radicle of *Cicer arietinum* at different period of germination are shown in the table I, and graphically represented in Fig. 2. These results indicate the gradual synthesis of both acid and alkaline phosphatase with the progress of germination. Comparatively there was much more higher synthesis of acid phosphatase than the alkaline one and this shows that acid phosphatase is largely required for the metabolic function during the process of growth of plants at its initial stage. In these cases there was a sudden rise in the activity after 2nd day

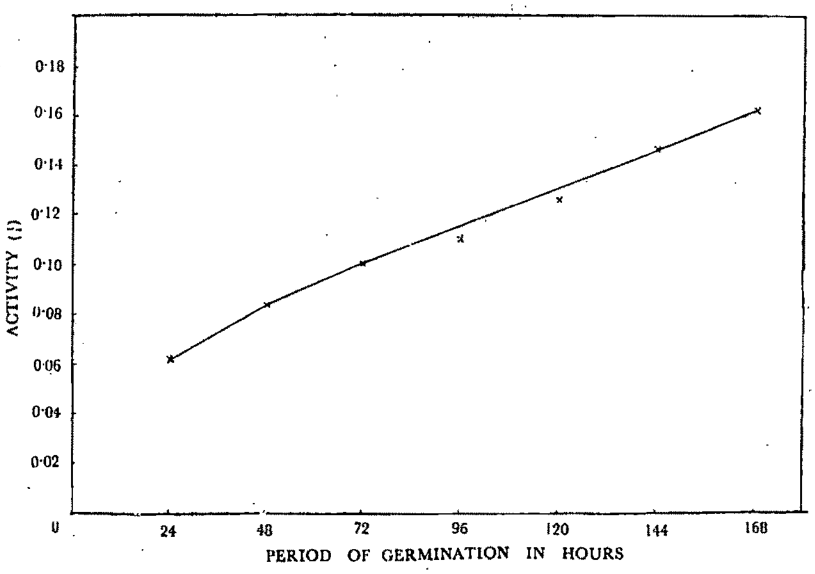

FIG. 2 Showing the relationship between the period of germination and percent absorption of light due to acid, & alkaline Phosphatases add phosphorylase in Radicle of Gram.

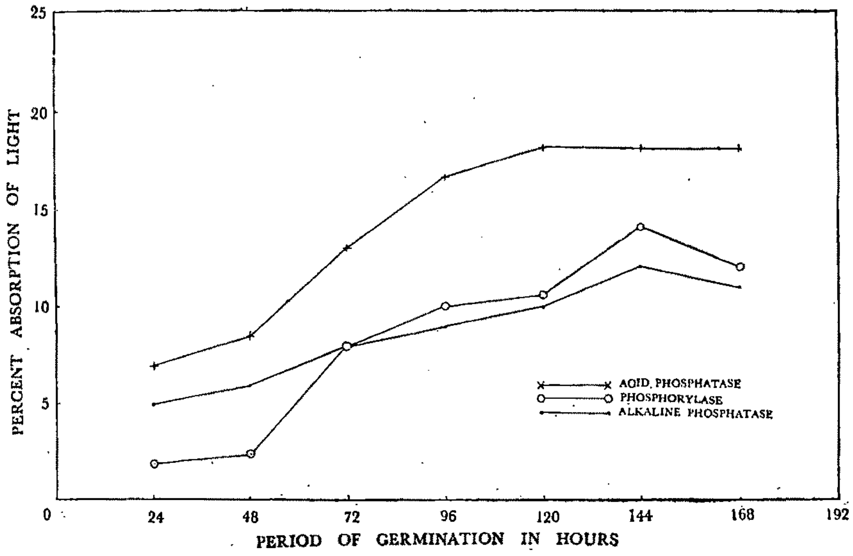

FIG. 3 Showing the relationship between the activity of esterase (1/T) and the period of Germination.

and this is probably due to appearance of plumule during this period, for which there was a large demand for these enzymes.

In case of phosphorylase also a gradual increase in the activity was noted with the progress of germination. Although at initial stage its activity was lower than alkaline phosphatase after third day it approached to same value and rather some what higher than alkaline phosphatase and followed the simila trend upto the last stage of germination on 7th day.

The data representing the activity of esterase of radicle at 24 hours intervals of germination period as deduced from the time of discharge of pink phenolphthalein colour are indicated in the table II and graphically represented by Fig. 3. From this table and graph it will be observed that after 24 hours of germination the time taken for discharge was 16 minutes and as the period of germination proceeds the time of discharge gradually decreases and on 7th day it reaches to minimum value of 6 minutes. Thus the activity calculated from the above table gradually increases from a low hypothetical value of 0.062 to 0.166 i.e., more than 2½ time at the final stage of germination. The above increase in the activity indicates the possibility of gradual synthesis required for the performance of metabolic function of the radicle during the process of germination.

SUMMARY

1 New method for the localisation and measurement of different enzymes in cells is reported and this is based on the application of a photocell and galvanometer attached to a microscope.

2. By this technique the alkaline and acid phosphatase, phosporylase and esterase activities in the radicle of *Cicer arietinum L* has been studied for a period of seven days during germination.

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ALKALINE BROMINE AS AN OXIDISING AGENT

ESTIMATION OF AMMONIA AND UREA

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While the theoretical possibilities of alkaline bromine as an oxidising agent are well recognised, the reagent has not been fully exploited in its practical aspects, due probably to two reasons: firstly the reluctance to handle liquid bromine and secondly its unsuitability as a primary standard. Both these defects could be overcome by making use of a mixture of $KBrO_3$ and KBr, from which the halogen could be liberated when needed by simple acidification and subsequently treated with alkali before use as oxidising agent.

Some work on the use of alkali hypobromite for estimation of aldoses was done by J. G. Shrikhande and Ram Dev (3) and the encouraging results reported by these authors have made further investigations worthwhile.

I have examined the bromate-bromide mixture in respect of its oxidation properties in alkaline medium and found it to be a very versatile oxidising agent which has some distinct advantages over iodine or chlorine analogues.

In this paper are given details which indicate that ammonia and urea can be quantitatively estimated without resort to the irksome processes of distillation or gasometry.

The standard gasometric method for the estimation of ammonia originally due to Knop (2) and Wagner (6) is based on the reaction:—

$$2NH_3+3[O] \longrightarrow 3H_2O+N_2$$

the oxidation being brought about by NaBrO. It was found that only 97.5% of the nitrogen are evolved (5) and, since, this constant proportion was always generated, a correction factor of 2.5% was introduced in the calculation of the results. Treadwell (4) pointed out that the correction factor could be avoided by carrying out the reaction at 100°C.

In a recent paper, Clusius and Rechnitz (1) have pointed out that contrary to previous observations, oxidation of ammonium salts by NaBrO does not give pure N_2, but that the gas contains 1.5-3% N_2O.

This gasometric method has its own obvious disadvantages and is usually avoided by most analysts.

Distillation of ammonia into a known excess of acid and subsequent titration is the more favoured method but this procedure can also be avoided by following the method described below.

EXPERIMENTAL

Solutions Required:—

(1) ($KBrO_3$ KBr) Mixture : 0.1 N (Standard) (Primary Standard)
(Prepared by dissolving 2.7840 gms. $KBrO_3$ and 9.91 gms. KBr and making up solution to 1000 c.c.)

(2) NaOH .... 1.0 N.

(3) HCl .... 2.0 N.

(4) KI .... 0.25 N.

(5) $Na_2S_2O_3\ 5\ H_2O$ .... 0.1 N. (Secondary Standard)

(6) Starch (fresh 1% solution)

(7) NH_4Cl .... 0.1 N. (for estimation)

(Prepared by dissolving 0.4456 gms. A.R. NH_4Cl in distilled water and made upto 250 c.c.)

Procedure

25 c.c. of standard "bromine" solution (bromate-bromide mixture) are pipetted out into a conical, stoppered flask of 750 c.c. capacity (usually employed for determination of Iodine value). The mouth of the flask is wetted with a few drops of NaOH to trap any bromine which might escape due to leakage from the stoppers. The solution is acidified with 2.10 c.c. of HCl (2N) and set aside for 10 minutes; 8.4 c.c. of (N)NaOH are now added (avoiding any undue exposure) and the contents of the flask well shaken. A definite volume (10 c.c.) of NH_4Cl solution is, then, added and the flask kept in boiling water bath for 15 minutes with occasional stirring. After cooling, 30 c.c. of KI (O.25 N) and, then, 30 c.c. of HCl (2N) are added and the flask is kept aside for, at least, 20 minutes. During this time the unused hypobromite liberates its equivalent of iodine from KI, which is subsequently titrated against 0.1 N $Na_2S_2O_3$. Blanks are simultaneously run with the same quantities of reagents minus NH_4Cl. The difference between the two titre values gives a measure of the ammonia oxidised.

EXPERIMENTAL

NH_4Cl solution $\equiv$ 0.4456 gms./250 c.c.

(Solution contains 0.01782 gms./10 c.c. NH_4Cl) 1 c.c. of prepared thiosulphate $\equiv$ 0.001786 gms. NH_4Cl.

Reaction at B. Pt. for 10-20 minutes.

TABLE No. I

No.	NH_4Cl in c.c.	NH_4cl in gms.	0.01 N. "Bromine" added in c.c.	$No_2S_2O_3$ Eq. of added "Bromine" in c.c.	$Na_2S_2O_3$ reading after oxidation in c.c.	"Br_2" reacted in terms of $Na_2S_2O_3$ in c.c.	NH_4Cl found in gms.	% Reaction
1	10	0.01782	10	9.9	5.7	4.2	0.00750	42.08
2	10	0.01782	15	14.9	9.0	5.9	0.01053	59.09
3	15	0.02673	25	24.9	14.0	10.9	0.01946	72.80
4	20	0.03564	35	34.9	18.9	16.0	0.02857	80.16
5	10	0.01782	20	19.9	10.9	9.0	0.01607	90.17
6	10	0.01782	25	24.9	14.9	10.0	0.0786	100.22
7	10	0.01782	25	24.9	14.9	10.0	0.01786	100.22
8	20	0.03564	50	49.9	29.9	20.0	0.03572	100.22

From these results it was concluded that, at least, 2.5 equivalents of bromine are to be added for complete oxidation of one equivalent of NH_4Cl.

Since, this reaction is capable of wide application a few experiments were carried out with a view to determine the smallest of ammonia that can be accurately estimated.

EXPERIMENTAL

NH_4Cl 0.01N. (0.1782 gms./1000 c.c).

"Bromine" solution = 0.01 N.

Sodium Thiosulphate = 0.01 N.

Reaction carried out at B. Pt. temperature for 10-20 minutes.

1 c.c. of prepared thiosulphate ≡ 0.1786 mgms.of NH_4Cl.

TABLE No. II

No.	NH_4Cl taken in c.c.	in mgms.	0.01 N. "Br_2" added in c.c.	$Na_2S_2O_3$ Eq. of added "Br_2" in c.c.	$Na_2S_2O_3$ reading after oxidation in c.c.	"Br_2' reacted in terms of $Na_2S_2O_3$ in c.c.	NH_4Cl found in mgms.	% Reaction
1	1	0.1782	2.5	2.4	1.5	0.9	0.1607	90.17
2	4	0.7128	10.0	9.9	6.1	3.8	0.6786	95.20
3	8	1.4256	20.0	19.9	12.1	7.8	1.3930	97.71
4	12	2.1384	30.0	29.9	18.1	11.8	2.1074	98.55
5	16	2.8512	40.0	39.9	23.9	16.0	2.8576	100.22
6	20	3.5640	50.0	49.9	29.9	20.0	3.5720	100.22
7	20	3.5640	50.0	49.9	29.9	20.0	3.5720	100.22
8	20	3.5640	50.0	49.9	29.9	20.0	3.5720	100.22

In the following series of experiments, the proportion of "Bromine" was further increased to three equivalents.

9	1	0.1782	3.0	2.9	2.0	0.9	0.1607	90.17
10	4	0.7128	12.0	11.9	8.0	3.9	0.6965	97.71
11	8	1.4256	24.0	23.9	15.9	8.0	1.4288	100.22
12	12	2.1384	36.0	35.9	23.9	12.0	2.1432	100.22

The proportion of "Bromine" was further increased to 3.5 equivalents in experiments 13 and 14 and to 4 equivalents in 15 and 16.

13	1	0.1782	3.5	3.4	2.5	0.9	0.1607	90.17
14	4	0.7128	14.0	13.9	9.9	4.0	0.7144	100.22
15	1	0.1782	4.0	3.9	2.9	1.0	0.1786	100.22
16	1	0.1782	4.0	3.9	2.9	1.0	0.1786	100.22

The results conclusively show that the method is applicable for the estimation of as little as 0.1782 mg. of NH_4Cl. The only condition to be remembered is that a larger equivalent (4 times) of bromate-bromide mixture is necessary for complete oxidation.

Parallel experiments carried out with alkali-hypoiodite solution prepared according to the method described in Treadwell and Hall:
Quantitative Analysis Vol. II as follows:—
"Iodite solution"

Dissolved 0.415 gms. of KI in as little water as possible. Add to this 2.5 c.c. of N.HCl and then 25 c.c. of 0.1 N KIO_3 solution. Make alkaline after 10 minutes.

TABLE III

No.	NH_4Cl solution taken in c.c.	0.1 Iodine solution taken in c.c.	$Na_2S_2O_3$ Eq. of Iodine added in c.c.	$Na_2S_2O_3$ Eq. of unreacted "Iodine in c.c.	$Na_2S_2O_3$ Eq. of reacted "Iodine"	NH_4Cl found in mgms.	% Reaction
1	10	10	9.9	9.9	....	....	nil
2	10	10	9.9	9.9	....	....	nil
3	10	20	19.9	19.9	....	....	nil
4	10	20	19.9	19.9	....	....	nil
5	10	30	29.9	29.9	....	....	nil
6	10	30	29.9	29.9	....	....	nil
7	10	40	39.9	39.9	....	....	nil
8	10	50	49.9	49.9	....	....	nil

The results indicate that no oxidation of NH_4Cl takes place with alkali-hypoiodite.

II Estimation of Urea
by
Alkali Hypobromite

Reactions Involved:—

$$3NaOBr + CO(NH_2)_2 \text{———————} N_2 + 2H_2O + CO_2 + 3\ NaBr$$

This reaction has been employed in the gasometric method of estimation of Urea in which a correction factor of +8.5% is introduced. (Vogel : Quan. Inorg. Anal . P. 777).

EXPERIMENTAL

Urea solution = 0.25 gm/250 c.c.

1 c.c. of $Na_2S_2O_3$ solution ≡ 0.0010 gms. urea.

TABLE IV

Reaction at B.Pt. temperature for 10-20 minutes.

No.	Urea solution taken in c.c.	Urea solution taken in gms.	0.1 N "Br_2" solution added in c.c.	$Na_2S_2O_3$ Eq. of Bromine added in c.c.	0.1 N "Br_2" unreacted in c.c.	0.1 N "Br_2" Reacted in c.c.	Urea found in gms.	% Reaction
1	10	0.010	10	9.9	5.8	4.1	0.0041	41.00
2	15	0.015	25	24.9	11.3	13.6	0.0136	90.66
3	10	0.010	20	19.9	10.4	9.5	0.0095	95.00
4	25	0.025	50	49.9	26.1	23.8	0.0238	95.20
5	10	0.010	25	24.9	14.9	10.0	0.0100	100.00
6	10	0.010	25	24.9	14.9	10.0	0.0100	100.00
7	20	0.020	50	49.9	29.9	20.0	0.0200	100.00
8	20	0.020	50	49.9	29.9	20.0	0.0200	100.00

From these results it was concluded that, at least, 2.5 equivalents of "Bromine" are required for complete oxidation of one equivalent of Urea.

A few experiments were carried out with alkali hypoiodite and urea. The results were negative, as in the case of NH_4Cl, and hence are not reproduced here. Urea is not oxidised by hypoiodite under the same conditions.

SUMMARY AND CONCLUSION

A mixture of $KBrO_3$ and KBr can be prepared and used as a primary standard as a source of "Bromine." The halogen can be generated when desired by simple acidification which by subsequent treatment with alkali can be used as a versatile oxidising agent. Ammonia and Urea can be quantitatively estimated by this method in preference to gasometric or distillation methods. 2.5 equivalents of the oxidising agent are ordinarily necessary for complete oxidation. In the case of smaller quantities of ammonia (0.1782 mgm.) a higher proportion upto 4 equivalents should be employed.

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ON VISCOSITY OF LIQUID MIXTURES

PART I LIQUIL-LIQUID BINARY MIXTURE

By R. P. SHUKLA and R. P. BHATNAGAR, *Department of Chemistry, Holkar College, Indore.*

CRITICISM OF THE PREVIOUS WORK

Fausto D. Lima (1) has tried to establish whether or not the formula

$$f(P) = d\Sigma_i x_i F_i / \Sigma_i x_i M_i = \frac{x_1F_1 + x_2F_2 + \ldots\ldots + x_nF_n.}{x_1M_1 + x_2M_2 + \ldots\ldots + x_nM_n} \times d,$$

[(Where f (p) is the function of the physical property concerned, x_i, is the mole fraction of the i^{th} component of the mixture, F_i, is the additive—constitutive property of the i^{th} function and M_i is the molecular weight of the i^{th} fraction)], could be applied to Souder's (2) viscosity constant, I. Further he has tried to calculate the viscosity of binary mixtures. But the percentage of error even when different K's are taken is too high. Thus if one looks at the table V^1 in case of alcohol-benzene, there is an error of 12.9% and in Butyl alcohol-benzene, 15%. The present work has been under taken with the idea of applying the reasoning of Katz and co-worker[3] in case of viscosity.

MODIFICATION OF SMITH'S AND KATZ'S (3, 4) FORMULA

Let F equal an additive—constitutive property, Rheochor, in case of viscosity. F is always the product of molecular volume M/d (M being the molecular weight in grams and 'd' is the density in grams/ c. c.) times the function of a physical property ($\eta,^{\frac{1}{8}}$ in case of viscosity) where η is the viscosity in millipoises). By putting this function of physical property $\eta^{\frac{1}{8}}$ as $f(\eta)$ we have $F = f(\eta)\, M/d$ for a pure compound. Now if for the i^{th} component of a mixture of 'i' component, the additive—constitutive property is designated by F_i, the molecular weight by M_i and the density of the mixture by 'd' the function of the physical property for the mixture by $f(\eta)$: then the value for 'F' for the mixture, as has been shown by Smith and co-worker (4), is obtained by

$F = \Sigma_i x_i F_i = x_1F_1 + x_2F_2 + \ldots\ldots\ldots\ldots\ldots + x_nF_n \ldots\ldots (1)$

or by $F = f(\eta)\ \Sigma_i x_i M_i/d = f(\eta) x (x_1M_1 + x_2M_2 + \ldots\ldots\ldots\ldots\ldots + x_{nn}M_n)/d$

(Where x_i, is the mole fraction of the i^{th} component of the mixture. By equating formulae (1) and 2 we get

$$F(\eta) = d\Sigma_i x_i F_i / \Sigma_i x_i M_i = \frac{x_1F_1 + x_2F_2 + \ldots\ldots\ldots\ldots + x_nF_n}{x_1M_1 + x_2M_2 + \ldots\ldots\ldots + x_nM_n.} \, xd \ldots (3)$$

Thus the physical property 'η' can be found out. This equation holds good for surface tension and molar polarisation (3, 4). The values of F_1, F_2, etc. can be calculated from the additivity of the groups or the atomic values of the molecules and corresponds to the rheochor of the components. Hence the viscosity of the mixture can be calculated as $F(\eta)$ corresponds to the eighth root of the viscosity. If R_1, R_2 etc. are the rheochor-s of the components 1,2, etc. and $x_1M_1+x_2M_2+\dots\dots\dots+x_nM_n=M_m$, the mean molecular weight, while η_m=the viscosity of the mixture, then the equation (3) will give

$$\eta_m^{\frac{1}{8}} = \frac{x_1R_1+x_2R_2+\dots\dots\dots+x_nR_n}{M_m} x d \dots\dots\dots (4)$$

We have also applied the above equation for the calculation of viscosity of binary mixtures.

RESULTS

We have utilised the data from the Silawat *et al.* (5) for the calculation of viscosity of mixtures. Our results are as follows:—

TABLE I

System : Toluene-Acetic acid : R_1=133.7; R_2=77.6

Temp.	x_1	x_2	'd'	M_m	$\eta x 10^3$ Cal.	$\eta x 10^3$ obs.	%error
30.0	0.0642	0.9358	1.015	62.1	9.6241	9.568	0.57
,,	0.2052	0.7948	0.9625	66.61	7.4872	7.538	0.67
,,	0.7929	0.2071	0.8676	85.47	5.3351	5.530	3.5
40.0	0.7929	0.2071	0.8511	4.725	4.859	4.725	2.82
50.0	0.0642	0.9358	0.9933	62.1	8.0801	8.122	0.52
,,	0.4800	0.5200	0.8855	78.44	4.8967	4.846	1.03

TABLE No. II

System: Benzene—acetic acid : R_1=110.4;R_2=77.6

Temp.	x_1	x_2	'd'	M_m	$\eta x 10^3$ cal.	$\eta x 10^3$ obs.	%error
30.0	0.1605	0.8397	0.9933	62.94	8.5617	8.519	0.50
,,	0.3900	0.6100	0.9430	67.08	6.889	6.887	0.03
,,	0.7224	0.2776	0.8964	73.06	5.9825	5.822	2.75
40.0	0.1605	0.8397	0.8664	62.94	7.8343	7.831	0.09
,,	0.7224	0.2776	0.8876	73.06	5.0788	5.111	0.63
50.0	0.7224	0.2776	0.8798	73.06	4.939	4.953	0.28

TABLE No. III

System: chloroform—acetic acid R_1=100.4; R_2=77.6

Temp.	x_1	x_2	'd'	M_m	$\eta x 10^3$ cal.	$\eta x 10^3$ obs.	%error.
30.0	0.0818	0.9181	1.074	64.90	8.8944	8.986	1.03
,,	0.2500	0.7500	1.151	74.90	7.2562	7.2562	0.17
40.0	0.0819	0.9181	1.064	64.90	8.2584	8.287	0.[illegible]
,,	0.7464	0.2536	1.347	104.30	4.7137	4.840	2.68
50.0	0.0819	0.9181	1.051	64.90	7.516	7.478	0.50
,,	0.7464	0.2536	1.334	104.30	4.6826	4.537	3.12

TABLE No. IV

System : Carbon tetra chloride—acetic acid; $R_1=122.0$; $R_2=77.6$

Temp.	x_1	x_2	'd'	M_m	$\eta x10^3$ cal.	$\eta x10^3$ Obs.	%error
30.0	0.0697	0.9363	1.110	66.59	10.715	10.71	0.04
”	0.2172	0.7828	1.228	80.36	9.9797	9.95	0.3
40.0	0.0697	0.9363	1.097	66.59	9.7942	9.82	4.4
”	0.7482	0.2518	1.517	130.2	7.8473	7.91	0.8
50.0	0.0697	0.9303	1.088	66.59	9.1336	9.17	0.4
”	0.2172	0.7828	1.196	80.36	8.0899	8.09	0.6

TABLE No. V

System : Toluene-acetone; $R_1=133.2$; $R_2=80.5$

Temp.	x_1	x_2	'd'	M_m	$\eta x10^3$ cal.	$\eta x10^3$ obs.	% error
30.0	0.0929	0.9071	0.7938	62.21	3.2869	3.132	2.9
”	0.3964	0.6326	0.8228	70.54	4.1886	4.169	0.49
40.0	0.0929	0.9071	0.7825	61.21	2.9435	2.858	2.91
”	0.3974	0.3626	0.8162	70.54	3.8550	3.952	1.91
50.0	0.0929	0.9071	0.7714	61.21	2.6138	2.564	1.91
”	0.3674	0.6326	0.8021	70.54	3.416	3.416	3.57

CONCLUSION

Thus we see that with this equation the viscosity of binary liquid mixtures can be calculated with greater accuracy. By this equation maximum error of only 4% occurs and hence this is a better equation. Further work on binary solid-liquid mixture and ternary mixtures is being carried out and will be published at a latter date.

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A CRITICAL STUDY OF METHODS OF EVALUATING PARACHOR
PART II

By S. N. Kaveeshwar and W. V. Bhagwat, *Chemistry Laboratories, Holkar College, Indore.*

Fergusson and Kennedy (4) have shown that the index in the Macleod's equation is sensibly different from 4. Telang (18) suggests therefore the need of parachor revision. We have, therefore, examined the view point in this paper. We have further discussed whether parachor can rightly be called as molecular volume when surface tension is unity.

Sugden's parachor is derived from Macleod's empirical equation, $r=C(D\text{-}d)^4$ where r is the surface tension, D and d are the orthobaric densities of the liquid and the vapour respectively and C is a constant different for each liquid. Fowler (5) has derived this equation in the neighbourhood of critical temperature. Telang (17) has derived the same expression under limited conditions. Fergusson and Kennedy (4) write the Macleod's equation as;

$$r=C(D\text{-}d)^p$$

Since p varies from substance to substance $MC^{\frac{1}{4}}=P$ has no natural significance. They therefore express parachor in the revised form $P_r=MC^{\frac{1}{p}}$ Sugden's parachor is not independant of temperature (15) as it should be. Same observation is made by Quayle and co-workers (7, 8, 9, 10, 11).

A large amount of data is now available on the surface tensions and densities at different temperatures (Compare Quayle (7, 8, 9, 10, 11) and Vogel (19, 20, 21, 22, 23, 24, 25). It is possible therefore to examine the suggestion of Fergusson and Kennedy (4) that parachor be revised, since p is not equal to 4 and that it varies from substance to substance.

$$\text{Since } r=C(D\text{-}d)^p \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\text{Log } r=\text{Log } C+p\log (D\text{-}d) \quad\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

and for any two temperatures

$$\text{Log } r_1=\text{Log } C+p \text{ Log } (D_1\text{-}d_1)$$

$$\text{Log } r_2=\text{Log } C+p \text{ Log } (D_2\text{-}d_2)$$

At ordinary temperatures d_1 and d_2 may be neglected. Hence,

$$\text{Log } r_1-\text{Log } r_2=p\ (\text{Log } D_1\text{-Log } D_2)$$

Thus both p and C can be found and it is possible to see whether they are constants and thus independant of temperature. Our results in case of hydrocarbons are given below. The value of D and r in case of benzene and its homologues are taken from the work of R. E. Donaldson and O. R. Quayle (11) and from Sugden (15).

Methyl Formate

50	20.48	0.9251		2.300	2.372	138.0	142.3
			4.06				
80	15.95	0.8698		2.297	2.361	137.8	141.7
			3.90				
110	11.77	0.8084		2.301	2.358	138.0	141.6
			3.69				
140	7.63	0.7156		2.322	2.369	139.3	142.2
			4.03				
170	3.96	0.6081		2.319	2.345	139.2	140.7
			3.77				
200	0.92	0.4131		2.370	2.366	142.2	142.6

mean $P_{50\text{-}200}=3.848$

Methyl alcohol

20	22.61	0.7910		2.757	2.895	88.10	92.74
			3.311				
70	18.50	0.7445		2.787	2.916	89.28	93.42
			3.422				
100	15.73	0.7100		2.804	2.928	89.82	93.80
			3.518				
130	12.66	0.6676		2.826	2.941	90.51	94.19
			3.649				
160	9.34	0.6141		2.826	2.947	91.16	94.39
			3.843				
190	5.56	0.5369		2.866	2.939	91.81	94.11
			3.673				
220	1.95	0.4036		2.928	2.952	93.80	94.56
			4.134				
230	0.77	0.3223		2.905	2.961	93.05	94.56

mean $P_{20\text{-}230}=3.764$

Benzene

t°C	r	D-d	p	$\frac{r^{\frac{1}{4}}}{D\text{-}d}$	$\frac{r^{\frac{1}{p}}}{D\text{-}d}$	P_s	Pr
13.5	29.72	0.8857		2.637	2.669	206.0	208.2
			3.67				
20	28.88	0.8787		2.638	2.670	206.1	208.3
			7.20				
21	28.74	0.8777		2.638	2.668	206.1	208.1
			3.41				
32.5	27.30	0.8653		2.642	2.673	206.4	208.4
			4.64				
34.5	26.98	0.8631		2.641	2.671	206.4	208.4
			4.04				
39	26.36	0.8581		2.641	2.671	206.4	208.4
			3.57				
41.5	26.08	0.8553		2.642	2.672	206.4	208.4
			3.90				

t°C	r	D-d	p	$\frac{r^{\frac{1}{4}}}{D-d}$	$\frac{r^{\frac{1}{p}}}{D-d}$	P_s	P_r
			Ethyl alcohol				
20	22.27	0.7888		2.755	2.889	127.6	132.9
			3.106				
80	17.97	0.7360		2.797	2.923	128.6	134.4
			4.206				
110	14.49	0.7008		2.785	2.900	128.1	133.6
			3.367				
140	11.34	0.6516		2.817	2.923	129.5	134.4
			3.829				
170	7.85	0.5920		2.828	2.918	130.1	134.2
			3.484				
200	4.26	0.5050		2.845	2.908	130.8	133.8
			3.830				
230	0.95	0.3415		2.891	2.888	132.9	132.9
			mean $P_{20-230}=3.769$				
			Ethyl acetate				
90	15.74	0.8065		2.470	2.558	182.8	189.2
			4.27				
120	12.08	0.7580		2.450	2.539	181.3	187.7
			3.94				
150	8.85	0.7005		2.462	2.530	182.4	187.2
			3.94				
180	5.70	0.6265		2.467	2.552	182.5	186.6
			3.69				
210	2.94	0.5232		2.500	2.537	184.9	187.7
			3.79				
240	0.50	0.3278		2.560	2.543	185.3	188.7
			mean $P_{90-240}=3.806$				

TABLE I

Benzene and its homologues

Compound	t°C	D	r	p	P_{mean}
Benzene	20	0.8790	28.87		
				3.94	
	30	0.8683	27.49		4.00
				4.06	
	40	0.8576	26.14		
Methyl benzene	20	0.8669	28.53		
				4.00	
	30	0.8576	27.32		3.99
				3.98	
	40	0.8483	26.15		
Ethyl benzene	20	0.8669	29.04		
				3.84	
	30	0.8582	27.93		3.93
				4.02	
	40	0.8494	26.79		
Propyl benzene	20	0.8620	28.99		
				3.75	
	30	0.8534	27.91		3.95
				4.17	
	40	0.8451	26.81		

TABLE II

Acetic acid

t°C	r	D-d	p	$\frac{r^{\frac{1}{4}}}{D-d}$	$\frac{r^{\frac{1}{p}}}{D-d}$	P_s	P_r
130	17.05	0.9190		2.211	2.326	132.66	139.56
			3.542				
160	14.21	0.8729		2.224	2.332	133.44	139.82
			3.778				
190	11.45	0.8245		2.231	2.330	133.86	139.82
			3.603				
220	8.71	0.7643		2.248	2.336	134.88	140.16
			3.835				
250	5.70	0.6841		2.258	2.238	135.48	139.68
			3.768				
280	2.83	0.5685		2.281	2.324	136.86	139.44

mean $P_{130-280}=3.734$

Carbon tetrachloride

t°C	r	D-d	p	$\frac{r^{\frac{1}{4}}}{D-d}$	$\frac{r^{\frac{1}{p}}}{D-d}$	Ps	Pr
20	26.95	1.593		1.429	1.409	219.8	216.6
			7.80				
21.1	26.71	1.591		1.428	1.408	219.6	216.5
			3.79				
33	25.22	1.567		1.429	1.410	219.8	216.8
			3.71				
45.9	23.63	1.540		1.432	1.412	220.2	217.1
			3.97				
90	18.51	1.475		1.433	1.415	220.4	217.6
			4.07				
120	14.95	1.374		1.431	1.414	220.1	217.4
			4.62				
150	11.46	1.291		1.425	1.409	219.2	216.6
			3.87				
180	8.50	1.194		1.429	1.415	219.8	217.6
			4.12				
240	2.694	0.898		1.419	1.414	218.2	217.4
			4.09				
270	0.4	0.595		1.405	1.402	216.6	215.6

$P_{20-270}=4.072$

Di ethyl ether

20	17.01	0.7109		2.857	2.887	211.8	214.2
			3.78				
50	13.69	0.6713		2.865	2.884	212.4	213.7
			4.41				
80	10.25	0.6286		2.850	2.872	211.3	212.9
			3.94				
110	7.00	0.5707		2.850	2.872	211.3	212.9
			3.85				
140	4.00	0.4936		2.865	2.880	212.4	213.7
			3.90				
170	1.42	0.3785		2.884	2.887	213.7	214.2
54.8	24.28	0.8400		2.642	2.673	206.4	208.4
			3.27				
61	23.61	0.8330		2.647	2.676	206.5	208.7
			4.33				
72	22.15	0.8207		2.643	2.673	206.7	208.4
			3.89				
90	20.13	0.8006		2.646	2.674	206.7	208.5
			4.06				
120	16.42	0.7616		2.643	2.669	206.5	208.2
			3.84				
150	13.01	0.7166		2.650	2.674	207.0	208.5
			4.18				
180	9.56	0.6657		2.641	2.663	206.4	207.7
			3.80				
210	6.45	0.6011		2.651	2.673	207.1	208.4
			3.96				
240	3.47	0.5137		2.657	2.662	207.5	207.6

P_{mean} 13.5-240=3.944

Chloro benzene

12	34.36	1.118		2.116	2.172	243.9	244.3
			3.36				
18.7	33.35	1.108		2.173	2.167	244.6	243.7
			2.91				
24.1	32.85	1.102		2.172	2.178	244.5	245.0
			3.75				
41	30.78	1.083		2.174	2.181	244.7	245.3
			3.40				
50	29.83	1.073		2.178	2.183	245.2	245.6
			5.42				
52.2	29.38	1.070		2.175	2.183	244.9	245.6
			3.96				
62.1	28.20	1.059		2.176	2.181	245.0	245.3
			4.00				
81	26.10	1.039		2.176	2.181	245.0	245.3
			3.24				
93	24.99	1.025		2.182	2.187	245.7	246.0
			4.30				
123	21.63	0.991		2.176	2.181	245.0	245.7
			4.01				

150	18.55	0.9545		2.174	2.180	244.7	245.2
			4.01				
180	15.40	0.9122		2.172	2.176	244.4	244.7
			4.02				
210	12.16	0.8422		2.166	2.168	243.9	245.9
			3.01				
240	9.30	0.8054		2.168	2.170	245.2	244.1
			3.99				
270	6.43	0.7341		2.169	2.171	245.3	244.2

P_{mean} 12-270=3.988

Fergusson (3) and Telang (17,18) object to parachor being called molecular volume when $r=1$ and state that it is to be interpreted in terms of energy. Molecular volume, according to Kopp's rule, is given by molecular weight divided by the density at the boiling point and the rule is an approximation. It is obvious that d being very small even at the boiling point, the values of M/D and M/(D-d) will not appreciably differ and hence Kopp, probably, did not find any necessity to introduce d in the molecular volume. And as far as dimensions are concerned M/D and M/(D-d) will not make any difference.

The author further states that from (2) Log C=Log r when $(D-d)=1$. It is obvious that this equation will not hold in for substances with D less than unity. Probably a better way of interpreting parachor is given by Quayle (12) when he says that parachor is made up of 'chore volume' and sphere of influence of the molecule. Furthermore Herzog (6) has shown a simple ratio exists between P and V_c and Sudgen (16) has compared P with the cross sectional or 'collision' area found from viscosity measurements.

From (2) for any particular liquid the value of p should be independent of temperature. Tables I and II show the value of p is not constant and varies from 3. 1 to 7. 2 and only when the value of p is taken for the largest temperature difference that the values of Pr become constant and near the observed value.

Telang (18) states that the values of Pr obviate the necessity of Sidgwick's (14) suggestion to account for the parachor anomaly of associated liquids. Many papers published from this laboratory have shown that the anamoly is due to parachor drop owing to the hydrogen bridge, which, it is well known, is responsible for the association of the lower alcohol and fatty acids. Bhagwat, Shukla and Khandekar (1) and Bhagwat, Kaveeshwar and Trivedi (2) have shown the presence of the H-bond in case of solution of amides in ethers and found the parachor drop is of 8-10 units. It is also worth noting that the values of P_{obs} for associated liquids are lower by this amount at ordinary temperatures and approach P_{calc} as the temperature is increased showing thereby that the H-bond becomes weaker with temperature rise and normal value of P_{calc} gets restored.

Thus the Fergusson and Kennedy equation is not an improvement over Sugden's simple and generalised equation. O. R. Quayle (13) has come to the same conclusion from different considerations.

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PARACHOR AND HYDROGEN BOND

PART IV. CO-ORDINATION OF PYRIDINE WITH ALCOHOLS

By R. P. SHUKLA and W. V. BHAGWAT, *Department of Chemistry, Holkar College, Indore.*

It has been observed that Hammick and Andrews equation of binary liquid mixtures (3) fails in case when pyridine is dissolved in alcohols. It has been suggested that pyridine forms co-ordination compound with ethyl and methyl alcohols as suggested by (Mlle) S. Hallen and co-workers (2) Our results are summarised in the following tables:—

(T, r, and P have usual meaning.)

Pyridine in methyl alcohol

TABLE I

Ratio of the moles of Py: MeOH :: 1:1.

Wt. of Pyridine	wt. of MeOH	T°C	'd'	'r'	P
79.14 Gms.	32.04 gms.	29.5	0.91157	27.983	280.29
26.38 ”	10.68 ”	29.6	0.91155	27.981	280.54
15.83 ”	6.41 ”	29.4	0.91157	27.879	281.49

TABLE II

Ratio of the moles of Py : MeOH :: 1 : 2.

Wt. of Pyridine	wt. of MeOH	T°C	'd'	'r'	'P'
79.10 gms.	64.08 gms.	30.5	0.88389	26.394	367.20
26.38 ”	21.36 ”	30.4	0.88390	26.394	367.20
15.83 ”	12.82 ”	30.4	0.88392	26.396	367.28

TABLE III

Ratio of the moles of Py : MeOH :: 1 : 3

Wt. of Pyridine	wt. of MeOH	T°C	'd'	'r'	'P'
79.10 gms.	96.12 gms.	29.8	0.86536	25.621	455.51
19.78 ”	24.03 ”	29.7	0.86538	25.628	455.40
13.19 ”	16.02 ”	30.0	0.86532	25.619	455.51

TABLE IV

Ratio of the moles of Py : MeOH :: 1 : 4.

Wt. of Pyridine	wt. of MeOH	T°C	'd'	'r'	'P'
79.10 gms.	128.16 gms.	28.9	0.85292	24.238	539.21
26.38 ”	42.72 ”	29.9	0.85293	24.234	539.27
13.19 ”	21.36 ”	29.8	0.85294	24.240	539.27

TABLE V

Ratio of the moles of Py : MeOH :: 1 : 5.

Wt. of Pyridine	wt. of MeOH	T°C	'd'	'r'	'P'
79.10 gms.	160.20 gms.	30.0	0.84547	23.632	624.32
15.838 ”	30.035 ”	29.7	0.84552	23.625	624.16
7.915 ”	16.025 ”	30.0	0.84546	23.632	624.02

TABLE VI

Ratio of the moles of Py : MeOH :: 1 : 6

Wt. of Pyridine	wt. of MeOH	T°C	'd'	'r'	'P'
19.10 gms.	192.24 gms.	29.9	0.83928	17.750	664.51
13.19 ”	32.04 ”	29.8	0.83931	17.752	663.45
6.593 ”	16.02 ”	29.9	0.83929	17.753	663.54

Pridine in ethyl alcohol

TABLE I

Ratio of the moles of Py : EtOH :: 1 : 1.

Wt. of Pyridine	wt. of EtOH	T°C	'd'	'r'	'P'
79.10 gms.	46.07 gms.	29.7	0.89146	26.952	320.0
19.775 ”	11.52 ”	29.8	0.89145	26.951	320.04
9.887 ”	5.776 ”	29.7	0.89145	26.955	319.96

TABLE II

Ratio of the moles of Py : EtOH :: 1 : 2.

Wt. of Pyridine	wt. of EtOH	T°C	'd'	'r'	'P'
79.10 gms.	92.14 gms.	29.7	0.86079	25.078	445.12
19.775 ”	23.04 ”	29.7	0.86078	25.081	444.83
9.887 ”	12.52 ”	29.6	0.86082	25.075	445.04

Table III

Ratio of the moles of Py : EtOH :: 1 : 3

Wt. of Pyridine	wt. of EtOH	T°C	'd'	'r'	'P'
79.00 gms.	138.21 gms.	28.1	0.84469	24.462	572.13
23.366 "	46.08 "	27.9	0.84469	24.463	571.90
8.786 "	15.36 "	28.02	0.84471	24.468	572.14

Table IV

Ratio of the moles of Py : EtOH :: 1 : 4

Wt. of Pyridine	wt. of EtOH	T°C	'd'	'r'	'P'
19.775 gms.	46.08 gms.	29.9	0.83312	23.436	695.72
13.18 "	30.72 "	29.6	0.83315	23.438	695.51
6.590 "	15.36 "	29.6	0.83315	23.436	695.35

Table V

Ratio of the moles of Py : EtOH :: 1 : 5

Wt. of Pyridine	wt. of EtOH	T°C	'd'	'r'	'P'
19.775 gms.	57.600 gms.	28.0	0.82621	22.924	819.78
7.910 "	23.035 "	28.1	0.82623	22.925	819.71
3.955 "	11.517 "	28.3	0.82619	22.925	819.59

Table VI

Ratio of the moles of Py : EtOH :: 1 : 6

Wt. of Pyridine	wt. of EtOH	T°C	'd'	'r'	'P'
19.774 gms.	69.12 gms.	29.7	0.82078	18.466	897.64
9.887 "	34.560 "	29.9	0.82075	18.467	897.85
4.893 "	15.360 "	30.0	0.82073	18.467	898.05

Relative lowering in parachor

(A) Pyridine in methyl alcohol

Parachor of Pyridine=179.2.
Parachor of methyl alcohol=93.2

Ratio of the moles Py : MeOH	Calculated parachor $P_{\text{pyridine}}+nP_{\text{MeOH}}$	Obs. Parachor	Difference per mole of MeOH=lowering per mole of MeOH
1 : 1	290.0	280.3	10.6/1=10.6
1 : 2	384.1	367.2	16.9/2=8.45
1 : 3	477.3	455.5	21.8/3=7.26
1 : 4	570.5	539.2	31.3/4=7.83
1 : 5	663.7	624.0	39.7/4=7.94
1 : 6	756.9	664.5	92.4/6=15.4

Pyridine in Ethyl alcohol

Parachor of ethyl alcohol = 132.2

Ratio of the moles of Py : EtOH	calculated parachor $P_{pyridine}-nP_{EtOH}$	Obs. parachor	Diff. per mole of EtOH = lowering per mole of EtOH
1 : 1	329.9	320.0	9.9/1 = 9.9
1 : 2	462.1	445.1	17.9/2 = 8.5
1 : 3	594.3	572.1	22.2/3 = 7.4
1 : 4	726.5	695.6	30.8/4 = 7.7
1 : 5	858.7	819.7	39.0/7 = 7.8
1 : 6	990.9	897.9	93.0/6 = 15.5

DISCUSSION

As will be seen from the results when pyridine is mixed with alcohols in different ratios of their molecular weights we always get a lowering in parachor value. If no co-ordination or compound formation takes place we shall get the parachor of the mixture as the sum of the parachor of the constituent molecules. This lowering is maximum when more than five molecules of alcohols are added for every molecule of pyridine. This lowering must be due to co-ordination between alcohol and pyridine as has been observed by us in previous papers (4, 1). Our inference is confirmed by the work of (Mlle) S. Hallen and co-workers (2). When less of alcohol is added though the co-ordination takes place the excess of pyridine remains as solvent and hence the lowering is less.

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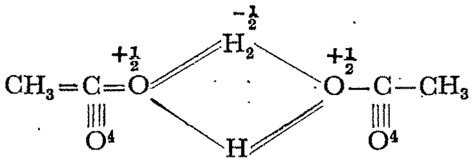
PARACHOR AND HYDROGEN BOND

PART VI. PARACHOR AND MECHANISM OF HYDROGEN BOND

By R. P. SHUKLA and W. V. BHAGWAT, *Department of Chemistry, Holkar College, Indore.*

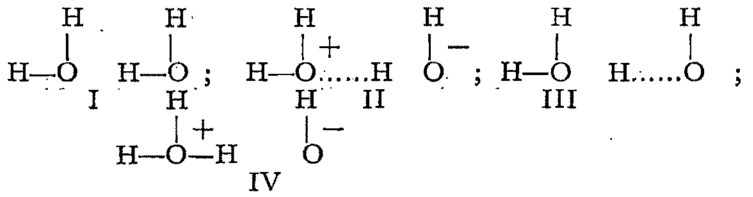
Sugden (13) while giving the cause for the negative anamolies in the parachor values of hydrogen bonded compounds thinks that hydrogen-bonding takes place by 'singlet linkages.' Discussing in the same lines as Sugden (13) D. C. Jones (9) suggested for associated liquids the same singlet linkages. Thus he has suggested the following structures for dimeric acids:

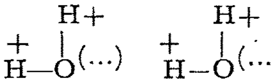


in which he has suggested three shared electrons to the hydrogen atom. This is contrary to Pauli's principle and also makes hydrogen atom negative and the oxygen atom attached to it positive consequently is not possible.

N. V. Sidgwick and Bayliss (14) studied the same problem by taking substituted phenols and their derivatives. According to them the co-ordination of hydrogen atom to form the group$=O\rightarrow H$ involves a decrease of 14.4 units in the parachor. If it is assumed that 1.6 of this are due to the transferred electrons, as Sugden finds in such linkages as $N\rightarrow O$ and $S\rightarrow O$ this rise in the co-valency of hydrogen from one to two will result in the contraction of 12.8 units. Thus he also attributes the hydrogen bonding to the valency increase and hence to actual donation of electrons but if this is so we should always get the same lowering in the parachor value. In actual practice in a series of papers (2, 3, 4, 5), published from this laboratory we have observed that the lowering is not the same.

At present it is usually convenient to separate the total inter-action between such chemically saturated molecules into the following terms (8):—(a) the dispersion or London forces (11) (b) dipole—dipole forces, (c) dipole induced dipole forces, (d)a force corresponding to resonance energy arising from the possibility of hydrogen atom occupying either of the two energy minima between the bonded atoms, (e) a repulsive force which falls very rapidly with the increasing distance. While dealing with these terms in our discussion we will deal with all these terms a,b,c and e in one term 'dipole—dipole interaction. Now we have to see whether dipole—dipole forces are only responsible or resonance also make any contribution in hydrogen bond. For this we will take the specific example of water. It can have the following resonating structures:—



In previous papers published in this journal (6) we have established the parachor conditions for the resonance to occur. Resonance can only occur if all the possible structures have identical parachor. It will be seen that the above structures have the same parachor value only the position of the atoms is different. Thus we can be sure that the part if not whole of the bonding is due to resonance. Still one cannot explain such a large lowering in the parachor value due to resonance. Though a small amount of lowering can take place. Sugden (15) attributes a decrease of 1.6 units for semipolar bond. This value is questioned by Subnis and Bhagwat (16). Anyway, it is clear that polar nature of the molecule causes decrease in the value of parachor. Hence the lowering in the value of parachor in case of hydrogen bond is due to the polar nature of the bond or in other words dipole—dipole forces are operating with the resonance in forming a hydrogen bond. The dimeric form of water can hence have one more highly polar resonating structure  $\overset{+}{\ }H{-}\overset{H+}{\overset{|}{O}}(\ldots)\quad \overset{+}{\ }H{-}\overset{H+}{\overset{|}{O}}(\ldots)$; which causes lowering in parachor. Similarly we can explain the hydrogen bond in other molecules. Thus according to our theory resonance combined with dipole—dipole forces is responsible for hydrogen bond. Our view is supported by the work of Baur and Magat (1), Martin (12), Davies (7) Ketelar (10), Uhlenbeck and others (17) etc.

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PARACHOR OF HYDROGEN ION : HYDRATED PROTON

By R. P. SHUKLA, R. P. BHATNAGAR and R. K. SHREEMAL, *Holkar College, Indore.*

Many attempts have been made to find the ionic radii (2, 4) (both by hydrated and unhydrated) but no body seems to have tried to find the ionic volume and ionic radius of hydrogen ion. The value is useful at many places. In finding the exchange affinities Kressman and Kitchner (1) have used the radii of various ions (hydrated) but they could do nothing for hydrogen ion. It will be interesting otherwise also, as the volume of hydrated proton. In this paper we have made an humble attempt to find the Parachor and thus the volume of hydrogen ion as Sugden (3) has proved that parachor is the measure of ionic volume. Following are our results:— (x, P_m, d. r, etc. have usual meaning)

Parachor of sulphuric acid

TABLE I

x (H_2SO_4)=O.20. 1−x(water)=O.80.

$M_m=34.0$.

temp.	'd'	'r'	P_m	Px	$2xP_H$' $[=PH_2SO_4\text{-}PSO''_4]$
21.4	1.0863	67.76	96.96	275.36	95.56
24.0	1.0056	67.15	96.77	274.41	94.61
32.3	1.0040	66.24	96.63	273.75	93.95

TABLE II

x (H_2SO_4)=0.10. 1−x(water)=0.90

$M_m=26.0$

temp.	'd'	'r'	P_m	P_x	$2xP_H$ $[=PH_2SO_4\text{-}PSO_4]$
21.4	1.0046	67.89	74.27	271.46	91.66
25.4	1.0038	67.13	74.11	269.9	90.10
30.7	1.0026	66.83	74.13	270.1	90.3

Parachor of hydrochloric acid

TABLE I

x(HCl)=0.20 1−x (water)=0.80

$M_m=21.70$

temp.	'd'	'r'	P_m	P_x	P_H $[=P_{HCl}\text{-}P_{Cl})$
22.5	1.0050	68.13	62.06	100.86	46.86
28.2	1.0035	67.74	62.04	100.76	46.76
30.3	1.0030	67.01	61.90	100.01	46.10

TABLE II

x(HCl) 0.05 $1 - x(\text{water}) = 0.95$

$M_m = 18.925$

temp.	'd'	'r'	P_m	P_x	$P_H(P_{HCl}-P_{Cl'})$
22.3	1.001	69.19	54.50	97.16	41.16
26.33	1.008	68.53	54.43	95.8	39.8
27.9	1.000	68.41	54.41	95.36	39.36

DISCUSSION

In a previous paper from this laboratory(5) it has been shown that the parachor of ions can be found out by simple mixture law. Working in the same lines we have found the parachor of different acids and from that the parachor value of anion is subtracted; thus the parachor the ionic volume of hydrogen ion can be found out. Thus $P_{H_2SO_4} - P_{SO''_4} = 2P_H$ and $P_{HCl} - P_{Cl'} = P_H$ In our case the parachor of sulphuric acid is 275.0 and the parachor of HCl is 100.86. The parachor value of SO''_4 and Cl′ ions have been found by Bhagwat and Shukla(5) to be 179.8 and 54.0 respectively. Hence the parachor of hydrogen ion an average will be 44.34.

If an ion is taken to be spherical the radius will be$=r=\left(\frac{3\times 44.34\times 7}{4\times 22}\right)^{\frac{1}{3}}$ $=2.196$. Krassman and Kitchner(1) have kept hydrogen ion (rather supposed it) to be greater than Li. ion and smaller than sodium ion. Our value 2.196 also comes in between lithium and sodium ions (hydrated).

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5. W. V. BHAGWAT and R. P. SHUKLA, 1952. *J. Indian chem. Soc.* **29** : 701.

EFFECT OF CHLORO GROUP ON THE OPTICAL ROTATORY POWER IN DERIVATIVES OF REYCHLER'S ACID

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The effect of halogens on the optical rotatory power has been studied by Tschugaeff (1), Cohen (2) and Hilditch (3). Their empirical observations, in general, lead to the conclusion that the introduction of halogens raises the value of rotatory power and that this value tends towards a constant in higher members of the series. This earlier work has, in general, not taken into account the physical factors such as temperature, concentration of the active substance, solvent and its nature and wavelength of light used which profoundly influence the observed value of optical rotatory power (4). In the present paper the authors have studied the effect of the chloro group in the derivatives of Reychler's acid under conditions in which the influence of the above mentioned physical factors has been practically eliminated.

EXPERIMENTAL

D-camphor-β-sulphonic acid: It was prepared according to the method described earlier by one of us (O. N. P.) (5). Found, M. P. 197-198°; $[M]^{16}_{5893} = +53.30$.

Anilino-D-camphor-β-sulphonate: It was prepared essentially by the method given by Shreiber and Shriner (6) from A. R. aniline distilled over zinc powder. Found, M. P. 161°.

p-Chloro-anilino-D-camphor-β-sulphonate: It was prepared by a method similar to that given by B. K. Singh and O. N. Perti (7). Found, M. P. 156°.

2 : 4 : 6-*Trichloro-anilino-D-camphor-β-sulphonate* : 1.97 g. of pure 2 : 4 : 6-trichloroaniline was dissolved in a suitable amount of alcohol free anhydrous ethyl acetate and separately 2.32 g. of pure recrystallised D-camphor-β-sulphonic acid was also dissolved in minimum amount of ethyl acetate. The two solutions were mixed and the product allowed to crystallise under anhydrous conditions.

Yield 2.1 g.; M. P. 124°
Found : Cl=26.20%, S=7.92%
$C_{10}H_{15}OSO_3H.H_2N.C_6H_2Cl_3$ requires Cl=26.07 %, S=7.83%.

To observe the effect of temperature, rotations for these compounds for Hg5461 at room temperature and at a higher temperature were recorded. These are given in Table I.

TABLE I

Formula $R=C_{10}H_{15}O.SO_3H$	Solvent	Conc. in g./100 ml	Room temp.		Higher temp.	
			°C	$[\alpha]_{5461}$	C°	$[\alpha]_{5461}$
$R.H_2N.C_6H_5$	water	0.9784	16.5	31.94	21	21.94
$R.H_2N.C_6H_4Cl$ (p-)	pyridine	0.9980	16	36.07	35	36.07
$R.H_2N.C_6H_2Cl_3(2:4:6)$	EtOH	1.0024	15	29.93	25	29.93

The rotatory power measurements were carried out in a 2 dcm. tube and the observations are recorded in Table II.

TABLE II

Rotatory power of 2 : 4 : 6-trichloranilino-D-camphor-β-sulphonate

Solvent	Concentration (g./100 ml)	Temp.	Wave length [λ]	Sp. rotation
Ethyl alcohol	1.0024	15°C	Ne6402	+13.27°
			Na5893	18.46
			Hg5780	21.45
			Hg5461	29.93
Methyl alcohol	1.0016	15	Ne6402	+14.97°
			Na5893	19.97
			Hg5780	21.96
			Hg5461	27.45
Pyridine	1.0000	14.5	Ne6402	+14.50°
			Na5893	21.50
			Hg5780	23.50
			Hg5461	30.00

The data given in Table II was analysed according to the method given by Lowry (8). In each case $1/\alpha$ was plotted against λ^2 and a straight line was obtaind indicating that the dispersion is simple and can be expressed by Drude's one term equation. These dispersion equations in the region of transparency were calculated out and were found to be as follows:—

Solvent	*Dispersion equation*
Ethyl alcohol	$\alpha=\frac{2.663}{\lambda^2-0.2091}$
Methyl alcohol	$\alpha=\frac{3.678}{\lambda^2-0.1641}$
Pyridine	$\alpha=\frac{3.089}{\lambda^2-0.1968}$

DISCUSSION

Table I indicates that there is no appreciable change in rotations of the compounds studied in the range 15 to 35° C approximately.

Anilino-D-camphor-β-sulphonate and p-chlor-anilino-D-camphor-β-sulphonate have been studied previously by one of us (O. N. P.) and have been shown to exhibit simple dispersion in methyl alcohol, ethyl alcohol and pyridine. (6, 7). Here it has been shown that 2:4:6-trichloroanilino-D-camphor-β-sulphonate also exhibits simple dispersion in these solvents. Thus it is perfectly valid to compare the rotatory power of these substances. This has been done in Table III.

TABLE III

Comparison of rotatory power

Name of compound	$[\alpha]_{5461}$ in solvent		
	Methyl alcohol	Ethyl alcohol	Pyridine
Anilino-D-camphor -β-sulphonate (6)	32.40	36.40	38.10
p-chloroanilino-D-camphor -β-sulphonate (7)	31.50	33.50	36.00
2:4:6-trichloroanilino-D-camphor-β-sulphonate	27.45	29.93	30.00

It is obvious from Table III that the sequence of rotatory power in methyl alcohol, ethyl alcohol or pyridine is in the order anilino-D-camphor-β-sulphonate > p-chloroanilino-D-camphor-β-sulphonate.

> 2 : 4 : 6-trichloroanilino-D-camphor-β-sulphonate.

This shows that in the case of derivatives of Reychler's acid studied in this paper, the rotatory power shows a decrease by increasing the number of chlorine atoms in the benzene nucleus. This result is not in general agreement with the earlier empirical generalisations. It is in agreement with the view that polar effect is traceable on optical rotatory power (9). According to this view, replacement of hydrogen by an electropositive group exhibits an increase in rotation (10) whereas substitution by an electronegative group causes a decrease in rotation (11). Here we find that substitution of electronegative chlorine in place of hydrogen causes a decrease in rotation.

CONCLUSION

In the case of aromatic amine derivatives of Reychler's acid, the rotatory power shows a decrease when electronegative chlorine is substituted in place of hydrogen in the aromatic nucleus. The rotatory power is studied in methyl alcohol, ethyl alcohol and pyridine in the region of transparency.

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ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

PART XII.—SECOND ANNOTATED CHECK-LIST OF INSECTS FROM THE NORTH-WEST (PUNJAB) HIMALAYAS

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Order HETEROPTERA

Family Pentatomidae

1. *Agonoscelis nubila* (Fabr.), Syst. Ent., p. 712 (1775) (Cimex); Distant, FBI, 1: 189 (1902)
   *Kashmir: Sind Valley. [Khasi Hills; Naga Hills; Calcutta; Bombay; Nilgiris; Mysore; Ceylon; Burma; Tenasserim; Malewoon; China; Japan.]
2. *Apodiphus pilipes* Horv., Termez. Füzetek, 12 : 29 (1889); Distant, FBI, 1 : 116 (1902).
   *Kashmir; *Gilgit.
3. *Carpocoris nigricornis* (Fabr.), Syst. Ent., 4 : 94 (1794) (Cimex); Distant, FBI, 1 : 158 (1902).
   *Kashmir: Sind Valley. [Simla; N. China; Japan; Yarkand.]
4. *Chilocoris nitidus* Mayr., Verh. z-b. Ges. Wien, 14 : 907 (1864); Distant, FBI, 1 : 105 (1902).
   *Kashmir. [Japan].
5. *Dalpada nigricollis* Westw., Cat. Hem., 1 : 22 (1837); Distant, FBI, 1 : 311 (1902).
   *Srinagar, Jhelum. [Nepal; Bengal.]
6. *Dolycoris leaccarum* (Linn.), Faun. Suec., 2 : 249 (1761) (Cimex); Distant, FBI, 1 : 159 (1902)
   *Kashmir, Sind Valley. [Bangalore.]
7. *Elasmucha tauriformis* Dist., Entom., 104 (1911); Distant, FBI, 7 : 150 (1918).
   *Muree.
8. *Eurydema festivum* (Linn.), Syst. Nat., 2 : 723 (1767) (*Cimex*); Distant, FBI, 1 : 191 (1902).
   *Kashmir; Sind Valley. [Madeira; Morocco; Turkistan; N. W. Siberia.]

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9. *Eurymenida vallicola* Bergr., Proc. U. S. Nat. Mus., 51 : 218 (1916) ; Distant, FBI, 7 : 142 (1918).
*Kashmir: Goorais Valley.

10. *Menida distincta* Distant, Tr. E. S., p. 122 (1879); FBI, 1 : 228 (1902).
*Muree, Sind Valley, *Kashmir.

11. *Mornidella pauli* Horv., Termes. Füzetek, 12 : 30 (1889); Distant, FBI, 1 : 150 (1902).
*Kashmir.

12. *Palomena reuteri* Dist., Tr. E. S., p. 122 (1879); FBI, 1 : 156 (1902).
*Kashmir; *Murree.

13. *Palomena viridissima* (Poda), Ins. Mus. Graec., p. 56 (1761) (Cimex); Distant, FBI, 1 : 156 (1902) .
*Murree. [Europe to N. W. Siberia.]

14. *Zicrona caerulea* (Linn.), Syst. Nat., 10 : 445 (1758) (Cimex); Distant, FBI, 1 : 255 (1902).
*Kashmir: Sind Valley. [Bengal; Naga Hills; Burma Karennae; China; Japan; Malaya.]

Family Coreidae.

15. *Cletus punctiger* (Dall.), List. Hem., 2 : 494 (1852) (Gonocerus); Distant, FBI, 1 : 393 (1902).
*Murree. [Calcutta. Pegu; Tikakyee; China.]

Family Lygaeidae.

16. *Aphanus dudgeoni* Dist., ANMH, (8) : 336 (1909); FBI, 5 : 69 (1910).
*Kangra Valley, 4500 ft.

17. *Aphanus kangricus* Kirk., Canad. Ent., 39 : 331 (1907); Distant, FBI, 5 : 67 (1910).
*Kangra Valley, 4500 ft.

18. *Caenocoris marginatus* (Thunb.), Kem. rostr. Cap., 3 : 3 (1922) (Alydus); Distant, FBI, 2 : 12 (1903).
*Kangra Valley. [Ceylon; Tenasserim; Palpoo; China.]

19. *Dieuches femoralis* Dohrn, Stett. Ent. Zeit., 21 : 405 (1860); Distant, FBI, 2 : 84 (1903).
*Kashmir. [Sikkim; Assam; Margharita; Naga Hills, Ceylon; Burma; Palon; Bhamo; Tenasserim; Malewoon; Batchian.]

20. *Dieuches leucoceras* (Walk.), Cat. Het., 5 : 101 (1872) (Rhyparochoromus); Distant, FBI, 2 : 83 (1903).
*Kashmir. [Bombay; Borghat; Ceylon; Bushirl.]

21. *Eremocoris indicus* Bredd., Wien. ent. Zeit., 26 : 96 (1907); Distant, FBI, 5 : 84 (1910).
*Kashmir.

22. *Lygaeus equistris* (Linn.), Fauna Suce., p. 253 (1746) (Cimex); Distant, FBI, 2 (1) : 7 (1903).
*Muree. [China; Japan.]

23. *Lygaeus sexatilis* (Scop.), Ent. Carn., p. 128 (1763) (Cimex); Distant, FBI, 5 : 4 (1910).
*Kashmir. [Sind; Widely distributed in Palaearctic region.]

24. *Nerthus dudgeoni* Dist., ANMH (8) 3 : 328 (1910); Distant, FBI, 5 : 33 (1910).
*Kangra Valley, 4500 ft.

25. *Polycrates nexus* Distant, FBI, 2 : 64 (1903).
*Kangra Valley, [Purma; Manhila.]

Family Pyrrhocoridae

26. *Antilochus coqueherti* (Fabr.), Syst. Rhyng, p. 222 (1803); (*Lygaeus*); Distant, FBI, 2(1) : 108 (1903).
*Kashmir. [Assam; N. Khasi Hills; Naga Hills; Calcutta; Secundrabad; Ceylon; Colombo; Burma; Tenasserim; Mt. Mooleyit.]

Family Phymantidae

27. *Glossopelta dudgeoni* Distant, Entomologist, 37 : 277 (1904); FBI, 5 : 127 (1910).
*Kangra Valley, 4500 ft.

Family REDUVIIDAE

28. *Lophocephala nicerta* Amy. & Serv., Hem., p. 386 (1843); Distant, FBI, 5 : 203 (1910).
*Kashmir. [Chatarpur.]

29. *Oncephalus annulipes* Stal., Ofv. Vet.-Ak. Forh., p. 44 (1855); Distant, FBI, 2 (1) : 231 (1903).
*Kashmir. [Bombay; Ceylon; Burma; Kanerree; Tenasserim; Meetan.]

30. *Oncephalus notatus* Klug, Symb. Phys., 2 : pl. XIX, fig. 1 (1830); Distant, FBI, 2 (1) : 227 (1903).
*Kashmir. [Borghat. Arihia deserta.]

Family HYDROMETRIDAE

31. *Velia currens* (Fabr.), Ent. Syst., 4 : 193 (1794) (*Geris*) Distant, FBI, 2 : 172 (1903).
*Muree. [Widely distributed throughout Palaearctic region.]

FAMILY GERRIDAE

32. *Gerris sahlbergi* Distant, Tr. E. S., 125 (1879); FBI, 2 (1) : 179 (1903).
*Ladak; *Leh.

Family NEPIDAE

33. *Ranatra elongata* Fabr., Skrivt. af. Naturh. Selsk., 1 : 228 (1790); Distant, FBI, 3 : 20 (1906).
*Kashmir. [Calcutta; Bombay; Nilgiris.]

34. *Laccotrephes ruber* (Linn), Mus. Lud., Ulr., p. 165 (1764) (Nepa); Distant, FBI, 3 : 18 (1906).
*Kashmir; *Kangra Valley. [Sind; Naga Hills; N. Khasi Hills; Bombay; Calcutta; Ceylon; Burma; Bhamo; China; Formosa; Japan.]

Family Belostomatidae

35. *Sphaeroderma molestum* (Duf.), Ann. Soc. Ent. France, p. 395 (1863); Distant, FBI, 3 : 36 (1906).
*Kashmir. [Calcutta; Malaca.]

Family Notonectidae

36. *Enithares lineatipes* Horv., Term Füzetek, 12 : 39 (1889); Distant; FBI, 3 : 43 (1906)
Himalaya; *Jhelum Valley. [[Tenasserim; Palpoo].

37. *Notonecta glauca* Linn., Sust. Nat., 10 : 439 (1758); Distant, FBI, 3 : 41 (1906).
*Kashmir, Sind Valley. [Yarkand; Throughout Palaearctic region.]

Order HOMOPTERA

Family Fulgoridae

1. *Flata ferrugata* (Fabr.), Syst. Rhych. p. 50 (1803) Distant, FBI, 3 : 429 (1906).
*Himalayas. Kangra Valley. [Tranquebar; Deccan; Maskaliya].

2. *Dictyophara nilgiriensis* Distant, FBI, 3 : 242 (1906).
*Kangra Valley. [Sikkim; Utakamand; Nilgiris; Tenasserim; Myitta.]

3. *Nesis versicolor* Distant, FBI, 3 : 234 (1906).
*Dalhousie.

4. *Zoraida pterophoroides* Westw., AMNH (2) 7 : 210 (1850); Distant, FBI, 3: 300 (1906).
*Kangra Valley. [Ceylon; Peradeniya; Upper Burma; Katha.]

Family Cicadidae

5. *Melempsalta literata* Dist., ANMH, (6) 1 : 375 (1888); FBI, 3 : 173 (1906).
*Kashmir Valley, 6300 ft.

6. *Paharia reticulator* (Dist.), ANMH, 6 (1) : 374 (1888) (Tibicen); FBI, 3: 164 (1906).
*Gilgit.

7. *Pycna repanda* (Linn.), Syst. Nat. p. 707 (1767) (Cicada) Distant, FBI, 3 : 71 (1906).
   *Kashmir Valley : [Bengal; Darjiling; Assam ; Sikkim; Burma; Khasi and Naga Hills.]

Family CERCOPIDAE

8. *Aphrophora brachycephala* Distant, FBI, 4 (1) : 101 (1907)
   *Kangra Valley, 4500 ft.
9. *Callitettix versicolor* (Fabr.), Ent. Syst., 4 : 50 (1794); Distant, FBI 4 (1) : 113 (1907).
   *Kashmir. [Mussoorie; Assam; Sikkim; Bombay; Burma; Bhamo; Thaijetmyo; Malaya Pennin. China; Perak; Akaran; Shwegu.]
10. *Cosmoscarta dorsalis* (Walk.) List. Hom., 3 : 658 (1851) (Cercopis); Distant, FBI, 4(1) : 146 (1907).
    *Kangra Valley. [Sikkim; Assam; Khasi Hills.]
11. *Cosmoscarta dorsimacula* (Walk.), List. Hom., 3 : 658 (1851) (Cercopis); Distant, FBI, (1) : 147 (1907)
    *Kangra Valley. [Mussoorie; Sikkim; Darjiling; Kurseong; Assam; Naga Hills.]

Family JASSIDAE

12. *Gypona ? kangraensis* (Kirk.), Wien. ent. Zeit., 24 : 26 (1905), Distant, FBI, 4(1) ; 264 (1907).
    *Kangra Valley.
13. *Kolla vesta* Distant, FBI, 4(1) : 224 (1907).
    *Kangra Valley.
14. *Pentithimia compacta* Walk., List. Hom. 3 : 842 (1851); Distant, FBI, 4(1) : 142 (1907).
    *Kangra Valley. [Bengal; Pusa; Bombay.]

Order COLEOPTERA

Family EROTYLIDAE

1. *Tetratritoma angusta* Arrow, FBI, Erotylidae p. 146 (1925).
   *Kashmir : Gulmarg 5000-9000 ft.
2. *Tritoma excellens* Arrow, FBI, Erotylidae p. 124 (1925).
   *Kashmir. [N.W.F. Provinces : Hazara Dist., Dungagali 8000 ft.]

Family ENDOMYCHIDAE

3. *Mycetina montivaga* Csiki, Termesz. Fiizetek, 23 : 401 (19001); FBI, Endomychidae p. 348 (1925).

*Kangra. *Kulu 700 ft. [Sikkim. Darjeeling 7000 ft. Assam: Khasi Hills, Shillong 5500 ft.—64000 ft. U. P. : W. Almora, Kumaon, Bhowali. Simla Hills. Kotgarh 7000 ft. Fagu 8000 ft.]

Family Scarabaeidae

4. *Caccobius denticollis* Har., Col. Hefte, 2 : 5 (1867) ; FBI, Lamellicornia 3 : 155 fig. 13 (1931).
*Kashmir : Pahlgam, Lidar Valley 7000 ft., Dardpur 6500 ft., Khurama 5500 ft., Lolab Valley. Punjab : Kulu, Kangra Dist. 7000 ft., [U. P. : Mussoorie 6000-7000 ft., Jaunsar, Chakrata; Konain, Chakrata 7800 ft. Simla Hills : Kotgarh 7000 ft., Fagu 8000 ft. Pindar Valley 8000-11000 ft. Sunderdhunga Valley, W. Almora 8000-12000 ft.]

5. *Caccobius himalayanus* (Jekel), Rev. mag. Zool., p. 411 (1872) (*Caccophilus*); FBI, Lamellicornia 3 : 153 fig. 12 (1931).
*Punjab : Kulu 4000 ft. *Kashmir : Lidarwat, Lidar Valley 9000 ft. Gulmarg 8500 ft., Pahlgam, Lidar Valley 7000 ft., Dardpur, Lolab Valley 6500 ft. Hardwan, Pohru Valley 6000 ft., Batote, Udhampur Division 5500 ft. [Punjab : Kotgarh, Simla, Hills 7000 ft., U. P., Konain 7800 ft., Kansar, Chakrata Dist. 7050 ft.]

6. *Copris excisus* Wat, AMNH, (6) 7 : 521 (1891); FBI, Lamellicornia 3 : 125 (1931).
*Gharial, Murree Hills 6000 ft.

7. *Copris sacontala* Redt., Hügel's Kaschmir, 4 (2) 519 (1848); FBI, Lamellicornia 3 : 104 pl. ix, figs. 15, 16 (1931).
*Thobba, Murree Hills. [U. P. W. Almora; Ranikhet, Allahabad, Almora, Kali Valley 8-10000 ft.]

8. *Copris sarpedon* Har., Col. Hefte, 4 : 104 (1868); FBI, Lamellicornia 3 : 110 pl. ix, figs. 1, 2 (1931).
*Kashmir : Botote, Udhampur Division 5500 ft., *Punjab : Thobba, Murree Hills, Dalhousie, [U. P : Mussoorie, Kampti Falls, Dhobi Ghat, Kanasar, Chakrata Dist. 7050 ft. W. Almora, Kumaon; Ranikhet., Assam: Shillong, Sylhet. Nepal. Siam.]

9. *Gymnopleurus flagellatus* (Fabr.), Mant. Ins., p. 17 (1787) (*Sacarabaeus*); FBI, Lamellicornia 3 : 55 (1931), pl. iii fig. 5.
*Kashmir : Harwan, Pohru Valley 6000 ft. [Baluchistan : Gwal Forest 6000 ft., Armarah. Waziristan, Afghanistan., Persia. Palestine, Morocco, Turkestan, Caucasia. Spain. S. France.]

10. *Gymnopleurus miliaris* (Fabr.), Syst. Ent., p. 817 (1775) (*Scarabaeus*); FBI Lamellicornia 3 : 50 pl. ii, fig. 3 (1931).
*Kashmir : Jhelum R. 5000 ft., Sonamarg 8600 ft. [N. W. F. P : Chitral. C. Prov : Nagpur. Jubbulpore. Orissa : Puri. Mysore:

Bangalore. Bengal : Berhampur. U. P : Fyzabad, Kakrighat, Naini Tal 5500 ft., Bombay : Belgaum., Bhutan., S. India : Tope, foot of Palni Hills. Ceylon : Wirawila in S. Province Kelani Valley near Colombo.]

11. *Oniticellus pallipes* (Fabr.), Spec. Ins., (1781) (*Scarabaeus*); FBI, Lamellicornia 3 : 375 fig. 52 (1931).
*Kashmir : Hutmara, Lidar Valley 6000 ft. [U. P : Arakct, Chakrata 4000 ft., Ghazipur, Jhajra, Dehra Dun, Sitapur; Fyzabad; Suswa R. Bengal : Calcutta, Sitapahar, Chittagong P. Hill Tracts. Bombay City. S. India : Madras City, Nilambur, Kodaikanal.]

12. *Oniticellus spinipes* Roth, Arch. Nat., 27 (1) 128 (1851); FBI, Lamellicornia 3 : 378 (1931).
*Kangra. [U. P : W. Almora, Sitapur Dehra Dun, Kampti Falls, Mussorrie. C. India : Amarkantak, Umaria, Rewa State 3200 ft. C. P : Nagpur. Bombay : Belgaum. Madras: Calicut, Nilambur; Abyssinia, Uganda, W. Africa, E. Africa, Rhodesia. Transvaal.]

13. *Onthophagus concolor* Sharp, J. Asiatic Soc. Bengal, 47 (2) 179 (1878); FBI, Lamellicornia 3 : 283 (1931).
*Kangra Valley, *Thobba, Murree Hills, *Kashmir : Batote, Udhampur Div. 5500 ft., Ferozepur Bullah, Gogaldara, Gulmarg 7000 ft., Killanmarg, Gulmarg 11000 ft., Harwan, Pohru Valley 6000 ft., Afan 5500 ft., Dardpur 6500 ft., Putshai 6000 ft., Nagmarg 10500 ft., Lolab Valley, Hutmara 6000 ft., Pahalgam 7000 ft., Frislina, Aru 8000 ft., Liderwat 9000 ft., Lidar Valley. [Punjab : Kotgarh, Simla Hills 7000 ft., U. P : Konain, Chakrata 7800 ft., Bodyar, 933 ft.]

14. *Onthophagus falsus* Gill, Ann. Soc. Sci. Brux., 44: 236 (1925); FBI, Lamellicornia 3 : 350 fig. 46 (1931).
*Kashmir. [Karachi, Dacca. Assam : Patkai Hills.]

15. *Onthophagus furcillifer* Bates, Entom., 24 Suppl., p. 11 (1891); FBI, Lamellicornia 3 : 273 (1931).
*Kashmir : Banihal 9000 ft., Ramban, Udhampur 2600 ft., *Punjab : Kulu; Murree 5500 ft. [U. P : W. Almora, Kumaon Mussoorie, Timli, Siwalik Hills, Ringal Gad, Dehra Dun, C. P : Ama Nala, Bilaspur 1400 ft., S. India : Kharkur Ghat, Malabar, Assam : Haflong, Cachar Dist., Shillong.]

16. *Onthophagus gibbosus* (Scriba), in FBI, Lamellicornia 3 : 219 (1931).
*Himalayas : Sutlej R. Tibet-Indian Frontier. [Turkestan. Persia, Asia Minor, E. Europe.]

17. *Onthophagus kuluensis* Bates, Entom., 24, Suppl., p. 12 (1891); FBI, Lamellicornia 3 : 292 fig. 35 (1931).
*Kashmir : Afan 5500 ft., Dorus 6000 ft., Putshai, Lolab Valley.

Punjab : Thobba, Murree Hills ; Kulu. [Punjab : Simla Fagu, Simla Hills. U. P : Mussorrie 7000 ft., Kampti Falls,.]

18. *Onthophagus lilliputanus* Lansb., Notes Leyd. Mus., 5 : 69 (1883); FBI, Lamellicornia 3 : 264 (1931).
*Kashmir; Sonamarg 8600 ft. [Punjab : Theog; Simla Hills 7600 ft., U. P : Mussorrie 6000-7000 ft., Kalsi, Jamuna R. Bengal : Rungpur. Bombay. Barkuda Is. Chilka, Ganjam Dist., Kanara, Coimbatore. Burma, Java, Borneo, Philippine Islands.]

19. *Onthophagus marginalis* (Gebl), Mem. Mosc., 5 : 315 (1817) (*Corpris*); FBI, Lamellicornia 3 : 247 fig. 26 (1931).
*Kashmir : Kurama, Lolab Valley 5500 ft., *Punjab : Jhelum 5000 ft. [Punjab : Simla . U. P : Arakot, Chakrata 4000 ft., Kotbhai, Giri R. 6500 ft. Dhobi Ghat, Mussorrie. Nepal, Afghanistan. Manchuria. Siberia. Persia,, Arabia, Caucaus.]

20. *Onthophagus mopsus* (Fabr.), Ent., Syst., 1 : 58 (1792) (*Sacarabacus*); FBI, Lamellicornia 3 : 328 (1931).
*Kashmir : Harwan, Pohru Valley 6000 ft., Haran, Sindh valley 5500 ft., Batote, Udhampur Div. 5500 ft. [Karachi, U. P : Fyzabad, Jhajra, Dehra Dun. Bihar : Pusa, Bengal : Calcutta, Berhampur, Darjeeling.]

21. *Onthophagus ramosellus* Bates, Entom. 24, Suppl., p. 11 (1891); FBI, Lamellicornia 3 : 217 (1931).
*Punjab : Kulu. [N. W. F. P : Taru, Peshawar Dist. Tarnab, Punjab : Lyallpur, U. P : Fyzabad, Suswa R., Dehra Dun; Ramgarh, Naini Tal 6500 ft. Haldwani, Jhajra, Dehra Dun, C. P : Sahahpur, Betul Distt., Hoshangabad, Narbada Bank 1000 ft., Nagpur, Bihar : Pusa, Chapra. Bengal : Calcutta, Hooghly Ghat, Rangpur, Berhampur; Assam : Tejpur; Upper Burma : Myingyan; S. India : Bangalore.]

22. *Onthophagus ramosus* (Wied), Zool. Mag., 2 (1) 13 (1823) (*Copris*); FBI, Lamellicornia 3 : 236 pl. xii, figs. 6, 7 (1931).
*Kashmir : Saidabad; *Punjab : Kangra Valley 4500 ft. [U. P : W. Almora, Dehra Dun, Chakrata Range Halwani; C. P : Motinala R., S. Mandla, Nagpur ; Bihar : Pussa; C. India : Mhow; Bombay : Belgaum; S. India : Mysore, Bangalore, Kanara, Pondicherry; Siam.]

23. *Onthophagus sutleinensis* Splich, DEZ, p. 567 (1910); FBI, Lamellicornia 3 : 249 (1931).
*Kashmir : Rajpur Rampur. *Tibet Frontier : R. Sutlej. [Punjab : Bashahra.]

24. *Onthophagus tibetanus* Arrow, AMNH, (7) 19 : 428 (1907); FBI, Lamellicornia 3 : 220 (1931).
*Kashmir : Killanmarg 10000 ft. [Tibet : Chaksam 12000 ft.,

Brahmaputra Valley, Gyangtse 13000 ft., U. P : Dhauli Ganga Valley Almora 10630 ft.]

25. *Onitis subopacus* Arrow, FBI, Lamellicornia 3 : 395 (1931).
*Kashmir : Haran Sind Valley 5500 ft., Harwan Pohru Valley 6000 ft.; [Nepal; Assam : Sylhet; Bengal : Calcutta, Singhla, Darjeeling Dist; Bihar : Pusa; U. P : Jhajra Dehra Dun; C. P : Baihar Balaghat, Supkhar 2629 ft. Balaghat ; C. India : Harai 2700 ft., Pharisamer Hills; S. India : Anamalai Hills ; Ceylon : Kalupahani Haldummulle; Burma; Tenasserim : Tavoy; Siam; Malay Peninsula.]

26. *Sisyphus indicus* Hope, Gray's Zool. Misc., p. 22 (1831); FBI, Lamellicornia 3 : 75 (1931).
*Kashmir : Batote Udhampur Div. 5500 ft. [Punjab : Phagu 7600 ft., Theog 7600 ft., Matiana 7900 ft., Simla Hills; Nepal; Sikkim : Pashok 2000 ft; Orissa : Barkul; Assam: Sylhet, Khasi Hills, Naga Hills.]

Family RUTELIDAE

27. *Adoretus caliginosus* Burm., Handb. Ent., 4 (1) 471 (1844); FBI, Lamellicornia 2 : 355 (1917).
*Kangra Valley 4500 ft. [Sikkim : Mungphu ; Bengal : Sarda; Bombay : Belgaum, Bandra; Madras : Nilgiris 3500 ft. ; Burma : Rangoon.]

28. *Adoretus ladakanus* Ohaus, DEZ, p. 484 (1914); FBI, Lamellicornia 2 : 335 (1917).
*Kashmir : Ladak; *Punjab : Murree.

29. *Adoretus lithobiux* Ohaus, DEZ. p. 485 fig. 16 (1914); FBI, Lamellicornia 2 : 335 fig. 71 (1917).
*Kulu; *Jhilam 5000 ft. [Punjab : Lahore; U. P : Ranikhet, Siahadevi 6000 ft.]

30. *Adoretus simplex* Sharp, J. Asiatic Soc. Bengal, 47 (2) 173 : (1878); FBI, Lamellicornia 2 : 329 pl. v., fig. 40 (1917).
*Kashmir : Sonamarg 8600 ft., *Punjab : Jhilam 5000 ft.

31. *Anomala chlorosoma* Arrow, FBI, Lamellicornia 2 : 231 pl. ii, fig. 15 (1917).
*Kangra Valley.

32. *Anomala dimidiata* (Hope), Gray's Zool. Misc., p. 23 (1831) (*Euchlora*); FBI, Lamellicornia 2 : 232 pl. ii, fig. 16 (1917).
*Kashmir; *Kulu; *Kangra Valley. [Punjab : Simla, Campbellpur; U. P; Chawai, Naini Tal 6000 ft., W. Almora, Ranikhet; Bengal : Maldah; Bihar : Pusa; Sikkim : Mungphu ; Assam : Shillong, Manipur, Khasi Hills.]

33. *Anomala fuviventris* (Blanch), Cat. Call. Ent. Mus. Paris, p. 235 (1851) (*Adoretosoma*); FBI, Lamellicornia 2 : 197 pl. iii, fig. 35 (1917).
*Kangra Valley. [Sikkim : Gopaldhara, Rungbong Valley, Kurseong, Pedong.]

34. *Anomala lineatopennis* Blanch, Cat. Coll. Ent. Mus. Paris, p. 191 (1851); FBI, Lamellicornia 2 : 212 (1917).
   *Kulu. [U. P : Dehra Dun, Mussorie, Ramgarh, Jolikote, W. Almora, Ranikhet, Naini Tal; Punjab : Simla; Bhutan; Nepal : Khatmandu; Bengal : Buxar Duars.]

35. *Anomala moorei* (Kraatz), DEZ, p. 294 (1892) (*Ischnopopillia*); FBI, Lamellicornia 2 : 265 (1917).
   *Chamba.

36. *Anomala rugosa* Arrow, Trans. Ent. Soc. London, p. 263 (1899) FBI, Lamellicornia 2 : 150 figs. 39 & 40 (1917).
   *Kulu. [Nepal; Sikkim : Sukna, Darjiling Dist. 1000 ft., Gopaldhara, Rungbong Valley; U. P : Jolikote, W. Almora.

37. *Anomala xanthonota* Arrow, FBI, Lamellicornia 2 : 244 fig. 53 (1917).
   *Dalhousie.

38. *Anomala xanthoptera* Blanch, Cat. Coll. Ent. Mus. Paris, p. 195 (1851); FBI, Lamellicornia 2 : 224 pl. ii, fig. 1 (1917).
   *Kulu; *Kangra Valley. [Dehra Dun.]

39. *Callistopopillia iris* (Candeze), Col. Hefte, 5 : 43 (1869) (*Anomala*); FBI, Lamellicornia 2 : 93 fig. 21 (1917).
   *Kashmir : Ladak. [Sikkim : Kurseong, Mungphu; Tibet: Yatong 10500 ft.]

40. *Mimela horsfieldi* Hope, Trans. Ent. Soc. London, 1 : 114 (1836); FBI, Lamellicornia 2 : 110 (1917).
   *Kulu; *Palampur. [Punjab : Simla; U. P : Ranikhet, Kusanie, 6000 ft., Kumaon; Nepal : Khatmandu; Sikkim : Kurseong, Gowchar; Assam : Jaintia Hills, Sibsagar.]

41. *Popillia cupricollis* Hope, Gray's Zool. Miscell., p. 23 (1831); FBI, Lamellicornia 2 : 73 (1917).
   *Kangra Valley; *Kulu. [Punjab : Simla, Kasauli; U. P : Mussoorie 7500 ft., Naini Tal, Kumaon 600 ft., Nepal; Sikkim: Kurseong 5000 ft., Soom, Darjiling Dist., Assam: Pedong.]

42. *Popillia cyanea* Hope, Gray's Zool. Miscell., p. 23 (1831); FBI, Lamellicornia 2 : 62 (1917).
   *W. Kashmir; *Kangra Valley. [N. Bengal : Siliguri U. P : Garhwal, Mussoorie 7500 ft., Kumaon, W. Almora; Nepal; Sikkim : Darjiling, Lebong 5000 ft., Assam : Naga and Pataki Hills.]

43. *Popillia sulcata* Redt., Hügel's Kaschmir, 4 (2) 527 (1948); FBI, Lamellicornia 2 : 89 (1917).
   *Kashmir. [U. P : Mussoorie, Landour.]

45. *Tropiorrhynchus podagricus* (Burm.), Handb. Ent., 4 (1) 226 (1844) (*Anisoplia*); FBI, Lamellicornia 2 : 55 (1917.)
   *Kashmir. [Bombay.]

Family DYNASTIDAE

46. *Alissonotum binodulum* (Fairm.), C. R. Soc. Ent. Belgique, 35 : 124 (1891); FBI, Lamellicornia 1 : 301 (1910).
*Kashmir : Gurias Valley 7000 ft., Sonamarg; *Punjab : Kulu.

47. *Heteronychus annulatus* Bates, The Entomologist, Suppl., p. 19 (1891); FBI, Lamellicornia 1 : 295 (1910).
*Kulu. [Calcutta.]

48. *Oryctes nasicornis* (L.), Syst. Nat., 1 : 346 (1758) (*Scarabaeus*); FBI, Lamellicornia 1 : 275 (1910).
*Kashmir. [Baluchistan; S. W. India; S. & S. E. Europe.]

Family CETONIDAE

49. *Anatona castanoptera* (Burm.), Handb. Ent., 3 : 509 (1842) (*Anoplochilus castonopterus*); FBI, Lamellicornia 1 : 116 (1910).
*Kulu. [Bombay.]

50. *Anatona stillata* (Newm.), Ent. Mag., 5 : 169 (1838) (*Cetonia*); FBI, Lamellicornia 1 : 114 (1910).
*Kangra Valley; *Kulu. [Punjab : Campbellpur; C. India : Mhow; Bombay : Kanara, Khandesh 3500 ft.; Madras : Bangalore.]

51. *Chiloloba acuta* (Wied.), Zool. Mag., 2 (1) 87 (1823) (*Cetonia*); FBI, Lamellicornia 1 : 172 (1910).
*Punjab : Murree, Kangra Valley. [Sikkim; U. P : Dehra Dun, Landaur; C. India : Mhow; Bombay : Belgaum; Madras: Bangalore, Malabar.]

52. *Dasyvalgus penicillatus* (Blanch.), Cat. Coll. Mus. Paris, p. 45 (1850) (*Valgus*); FBI, Lamellicornia 1 : 243 (1910).
*Kulu.

53. *Heterorrhina nigritarsis* (Hope), Gray's Zool. Miscell. p. 24 (1831) (*Cetonia*); FBI, Lamellicornia 1 : 99 (1910) pl. i, fig. 2 & 3.
*Kulu. [Nepal; U. P : Dehra Dun, Mussoorie; Sikkim : Darjiling.]

54. *Heterorrhina porphyretica* Westw., Trans. Ent. Soc. London, 5 : 2 pl. 16, fig. 1 (1849); FBI, Lamellicornia 1 : 100 (1910).
*Kulu.

55. *Protaetia impavida* (Janson), Cist. Ent., 2 : 538 (1879) (*Potosia*); FBI, Lamellicornia 1 : 145 (1910).
*Punjab : Kulu; *Kashmir : Gilgit. [N. W. F. P : Peshawar.]

56. *Protaetia orientalis* (G & P.), Monogr. Cet., p. 193 pl. 34 fig. 6 (1833) (*Cetonia*) FBI, Lamellicornia 1 : 143 (1910).
*Kashmir. [China; Formosa; Japan.]

57. *Rhomborrhina glaberrima* (Westw.), Arcana Ent., 1 : 136 pl. 34, fig. 1 (1842) (*Anomalocera*); FBI, Lamellicornia 1 : 87 (1910).
*Murree. [Mussoorie; Sikkim : Darjiling.]

58. *Thaumastopeus pullus* (Fröhlich), Naturf. Gesells. Halle, 26 : 110 (1792) (*Cetonia*); FBI, Lamellicornia 1 : 195 (1910).
*Kangra Valley. [W. Bengal : Nowatoli; Palkot; Bihar: Chapra; Assam : Naga Hills, Manipur; Bhutan : Maria Basti; Sikkim : Kurseong, Darjiling; Tenasserim; Andamans; Ceylon ; Malay Peninsula; Java.]

Family CERAMBYCIDAE

59. *Aegosoma buckleyi* Gahan, AMNH, (6) 14 : 227 (1894); FBI, 1 : 47 (1906).
*Dalhousie.

60. *Aeolesthes indicola* (Bates), Entomologist, 24, Suppl., p. 21 (1891) (*Neocereambyx*); FBI, 1 : 128 (1906).
*Kulu.

61. *Apatophysis kashmiriana* Semenow, Revue Russe d' Entom., 1 : 29 (1901); FBI, 1 : 70 fig. 26 (1906).
*Kashmir. [Punjab; Western Tibet.]

62. *Apatophysis montana* Gahan, FBI, 1 : 71 (1906).
*Between Gilgit and Nagy.

63. *Clytus monticola* Gahan, FBI, 1 : 251 (1906).
*Kashmir. [Western Tibet.]

64. *Ephies sulcipennis* Bates, Entomologist, 24, Suppl. p. 22 (1891); FBI, 1 : 88 (1906).
*Kulu.

65. *Leptura rubriola* Bates, PZS, p. 720 (1878); FBI, 1 : 88 fig. 33 (1906).
*Kashmir; *Murree; *Near Gulberg; *Lidder 11000 ft.

66. *Lophosternus hungelii* (Redtenb.), Hügel's Kaschmir, 4 (2) 550 pl. 28, fig. 1 (1848) (*Cyrtognathus*); FBI, 1 : 11 (1906).
*Kashmir. [N. W. Provinces; Punjab; Assam.]

67. *Macrotona crenata* (Fabr.), Syst. Eleuth., 2 : 264 (1801) (*Prionus*); FBI, 1 : 36 fig.. 13 (1906).
*Kashmir. [All the way from Kashmir to S. Bombay; Nepal to Calcutta; Ceylon; Burma.]

68. *Prionus corpulentus* Bates, PZS, p. 720 (1878); FBI, 1 : 15 fig. 4 (1906).
*Kashmir; *Murree.

69. *Purpuricenus haussknetchi* Witte, Berlin. ent. Zeit., 15 : 207 (1871); FBI, 1 : 186 (1906).
*Kashmir. [Punjab; Turkestan.]

70. *Purpuricenus montanus* White, Cat. Col. B. M., Longic., p. 138 (1853); FBI, 1 : 186 (1906).
*West Kashmir. [Campbellpur; Himalayas; Tibet.]

71. *Tetropium oreinum* Gahan, FBI, 1 : 95 fig. 37 (1906).
*West Kashmir; *N. W. Himalayas.

72. *Trinophylum cribratum* Bates, PZS, p. 720 (1878); FBI, 1 : 156 fig. 63 (1906).
*Kashmir; *Murree. [Assam; Sylhet.]

73. *Xylotrechus subditus* Chevr., Mem. Soc. R. Sci. de Liége, 18 : 314 (1863); FBI, 1 : 246 (1906).
*Kashmir.

Family CHRYSOMELIDAE

74. *Apthona andrewsi* Jacoby, Ann. Soc. Ent. Belgium, 40 : 256 (1896); FBI, Chrysomelinae & Halticinae p. 374 (1926).
*Chamba.

75. *Apthona hugeli* Jacoby, Mem. Soc. Ent. Belgium, 7 : 121 (1900) ; FBI, Chrysomelinae & Halticinae p. 371 fig. 125 (1946).
*Kashmir. [Bombay : Satara.]

76. *Apophylia sericea* (Fabricius), Suppl. Ent. Syst., p. 69 (1798) (*Cantharis*); FBI, Galerucinae p. 84 (1936).
*Kangra Valley 4500 ft. [Bengal : Calcutta, Sarda, Champaron, Buxa Duras; Bihar : Chapra; Assam : Sadiya, Cherrapunji; U. P : Haldwani, Kumaon, Almora; E. Himalayas : Lebong 5000 ft., Mungphu.]

77. *Aulacophora foveicollis* (Lucas), Explor. Algér. Ent., p. 542 pl. 44., fig. 9 (1849) (*Galerucella*); FBI, Galerucinae p. 173 fig. 52 (1936). *Kangra Valley. [Greece; S. Europe; Algeria; Egypt; Cyprus; Aden; Persia; Bombay; Madras; Travancore; Ceylon; Punjab; U. P : Nepal; Bengal; Assam; Burma; Andaman Islands.]

78. *Bromiodes indicus* Jac., Soc. Belgium, 39 : 287 (1895); FBI, 2 : 465 (1903).
*Dalhousie *Chamba.

79. *Chrysolina bella* (Jacoby), Entomologist, 23 : 253 (1890) (*Chrysomela*); FBI, Chrysomelinae & Halticinae p. 39 (1926).
*Chamba; *Kashmir. [Taru; Peshawar.]

80. *Chrysolina coelestina* (Baly), Trans. Ent. Soc. London, p. 193 (1879) (*Crostia*); FBI, Chrysomelinae & Halticinae p. 33 fig. 10 (1926).
*Kangra Valley 4500 ft. [Peshawar; Naini Tal; Dehra Dun; Simla; W. Almora; Kumaon; Landsdowne Div; N. China; Persia.]

81. *Chrysolina perforata* (Raedtenbacher), Hügel's Kaschmir, 4 : 557 (1848) (*Chrysomela*); FBI, Chrysomelinae & Halticinae p. 43 (1926).
*Kashmir.

82. *Chrysomela populi* L., Syst. Nat. ed., 10 : 370 (1758); FBI, Chrysomelinae & Halticinae p. 68 (1926).
*Kashmir. [Dungagali; Hazara Dist; Simla Hills; Matiana 8000 ft.; Phagu 9000 ft. Darjeeling; Ranikhet; W. Almora; Assam; Europe; N. Africa; N. & W. Asia; China; Japan.]

83. *Clytra dispar* Redtenb., Hügel's Kaschmir 4 (2) 560 (1848); FBI, 2 : 154 (1908).
*Kashmir.

84. *Clytrasoma conformis* Lacord., Mon. Phytoph., 2 : 194 (1848) (*Clythra*); FBI, 2 : 150 fig. 51 (1908).
*Kashmir. [Punjab; Bengal; Malabar.]

85. *Cneorane rugulipennis* Baly, Trans. Ent. Soc. London, p. 27 (1886); FBI, Galerucinae p. 339 (1936).
*Kangra Valley. [Almora; Chaubattia 6000-7000 ft. Darjeeling; Assam : Sadiya; Manipur; Burma: Ruby Mines.]

86. *Cryptocephalus kashmirensis* Jacoby, FBI, 2 : 261 (1908).
*Kashmir. [Punjab; Khasi Hills.]

87. *Cryptocephalus oppositus* Jacoby, FBI, 2 : 249 (1908).
*Kulu.

88. *Cryptocephalus sannio* Redtenb., Hügel's Kaschmir, 4 : 561 (1948); FBI, 2 : 251 fig. 96 (1908).
*Kashmir.

89. *Cryptocephalus tricinctus* Redtenb., Hügel's Kaschmir, 4 : 562 (1848); FBI, 2 : 237 fig. 86 (1908).
*Kashmir. [Mussoorie.]

90. *Dactylispa brevispinosa* (Chapuis), Ann. Soc. Ent. Belgium, 20 : 56 (1877) (*Hispa*); FBI, Hispinae & Cassidinae p. 183 fig. 57 (1919).
*Kangra Valley 4500 ft. [Assam : Khasi Hills 1000 ft.-3000 ft.]

91. *Dercetis dimidiaticornis* (Jacoby.), Entomologist, 24 : 33 (1891) (*Antipha*); FBI, Galerucinae p. 369 (1936).
*Kashmir.

92. *Diorhabda trirakha* Maulik, FBI, Galerucinae p. 236 (1936).
*Chamba State; *Pangi; *Pontu Reserve.

93. *Epimela ornata* (Redtenb.), Hügel's Reise Kaschmir, p. 560 pl. 28, fig. 5 (1846) (*Coptocephala*); FBI, 2 : 144 (1908).
*Kashmir.

94. *Eubrachis himalayensis* (Jac.), Mém. Soc. Ent. Belgium, 7 : 111 (1900) (*Pseudocolaspis*); FBI, 2 : 436 (1908).
*Chamba.

95. *Eubrachis indica* Baly, J. Linn. Soc., 14 : 249 (1877); FBI, 2 : 433 (1908).
*Kashmir. [Northern India; Punjab; Mussoorie.]

96. *Galeruca himalayensis* Jacoby, Ann. Soc. Ent. Belgium, 40 : 283 (1896); FBI, Galerucinae p. 100 (1936).
*Dalhousie.

97. *Galeruca sexcostata* Jacoby, Ann. Soc. Ent. Belgium, 48 : 405 (1904); FBI, Galerucinae p. 102 (1936).
*Kashmir : Lidder 1100 ft., Srinagar, Burzil-chauki 11700 ft. [Lahore.]

98. *Galerucella placida* Baly, Cist. Ent., 2 : 381 (1878); FBI, Galerucinae p. 217 (1936).
*Kashmir : Srinagar, Dal Lake 5500 ft. [U. P : Kumaon, Naini-Tal, Lucknow, Goomtia R.; Bihar : Pusa, Purneah, Kierpur,

Champarum, Hardia; Bengal : Burdwan, Sara Ghat, Goalbadhan, Chandpur, Dacca, Narayangunge; S. India: Coromandel, 2500 ft. ; Burma : Rangoon, Mandalay, Pyinmana 400 ft.]

99. *Gallercida bicolor* (Hope), Gray, Zool. Miscell., p. 29 (1831) (*Galleruca*); FBI, Galerucinae p. 554 (1936).
*Kangra Valley. [Nepal; Simla; U. P : Mussoorie, Dehra Dun, Garhwal Landsdowne; Darjeeling:Sitong, Pashok; Bombay; West Coast : Mormugao ; Malabar : Calicut, Palghat.]

100. *Gallerucida rutilans* (Hope), Gray, Zool. Miscell., p. 30 (1831) (*Eumolpus*); FBI, Galerucinae p. 547 (1936).
*Kangra Valley. [Simla; Garhwal; Landsdowne; Dehra Dun; Kumaon; Bhim Tal; Sikkim : Mungphu; Lebong; Gopaldhara; Ging; Kurseong; Kalimpong; Bengal; Assam.]

101. *Gynandropthalma signaticollis* (Redtenb.); Hügel's Reise Kaschmir, p. 561 (1846) (*Coptocephala*); FBI, 2 : 109 (1908).
*Kashmir.

102. *Labidostomis funerea* Fairm., Ann. Soc. Ent. Belgium, p. 103 (1891); FBI, 2 : 97 (1908).
*Kashmir.

103. *Labidostomis indica* Jacoby, Ann. Soc. Ent. Belgium, 39 : 254 (1895); FBI, 2 : 96 (1908).
*Kashmir; *Dalhousie.

104. *Leprotella cashmirensis* Jacoby, Mém. Soc. Ent. Belgium, 7 : 101 (1900); FBI, 2 : 415 (1908).
*Kashmir.

105. *Leptarthra collaris* Baly, Cist. Ent., 2 : 382 (1878); FBI, Galerucinae p. 611 (1936).
*Murree; *Chamba. [Thobba.]

106. *Leptosonyx octocostatus* Weise, Archiv. f. Naturgesch., 78 (A) 2 : 92 (1912); FBI, Galerucinae p. 75 (1936).
*Kashmir : Khalatse 15000 ft.

107. *Longitarsus cyanipennis* Byrant, ANMH, (9) 14 : 249 (1924); FBI, Chrysomelinae & Halticinae p. 337 (1926).
*Lahul. [U. P : Kumaon, Sarju Valley 5000 ft., Almora 7000-9000 ft., Naini Tal; Darjeeling : Gopaldhara.]

108. *Macrima armata* Baly, Cist. Ent., 2 : 377 (1878); FBI, Galerucinae p. 561 figs. 136 & 137 (1936).
*Kulu; *Jhelum Valley; *Kashmir. [Darjeeling : Debrepani, 6000 ft.]

109. *Merista quadrifaciata* (Hope), Gray Zool. Miscell., p. 28 (1831) (*Galleruca*); FBI, Galerucinae p. 149 (1936).
*Kashmir; *Ladak; *Kangra Valley 4500 ft. [Kumaon; Bhim Tal 4500 ft; Almora 5500 ft. Simla; Naini Tal; Nepal; Pharping; Gowchar; Soondrijal; Ranikhet; Muktesar; Mussoorie 7000

ft.; Dehra Dun; Abbotabad 4120 ft. Jolikoti; Rungbong Valley; Gopaldhara; Mungpu.] *Murree.

110. *Merista sexmacalata* (Kollar & Redtenbacher), Hügel's Kaschmir und das Reich der Siek, 4 : 555 fig. 5 (1848) (*Galleruca*); FBI, Galerucinae p. 145 (1936).
*Kashmir. [Muktesar 7500 ft.; Mussoorie; Almora; Naini Tal; Sunderdhunga Valley 8000-12000 ft. E. Himalayas : Kurseong, Darjeeling, Gangtok, Gopaldhara; Orissa : Chandipore.]

111. *Mimastra cyanura* (Hope), Gray, Zool. Miscell., p. 229 (1831) (*Auchenia*); FBI, Galerucinae p. 529 (1936).
*Kashmir. [Nepal; Mussoorie; Manipur; Burma : Ruby Mines; Karen Mts., Northern Chin Hills.]

112. *Miochira montana* (Jacoby), Ann. Soc. Ent. Belgium, 39 : 255 (1895) (*Clythra*); FBI, 2 : 160 fig. 58 (1908).
*Dalhousie. [Simla Hills; Assam : Khasi Hills.]

113. *Oedicerus cyanipennis* Kollar & Redtenbacher, Hügel Kaschmir und das Reich der Siek 4 : 557 (1848); FBI, Galerucinae p. 469 fig. 119 (1936).
*Kashmir.

114. *Platypria andrewesi* Weise, DEZ, p. 404 (1906) FBI, Hispinae & Cassidinae p. 260 (1919).
*Kangra Valley, 4500 ft. [C. P : Nagpur; Bombay : Surat; Madras : Hajari.]

115. *Psylliodes tenebrosus* Jacoby, Ann. Soc. Ent. Belgique, 40 : 269 (1896); FBI, Chrysomelinae & Halticinae p. 129 (1926).
*Chamba. [U. P : Chaubattia in Almora Dist., 6000-7000 ft., South Garhwal 6500 ft., Sukhatal 8000 ft., Dudhatoli 8000-10000 ft., Naini Tal 7000-8500 ft., Jaolikoti, Bhim Tal.]

116. *Scelodonta longicollis* Jacoby, FBI, 2 : 387 (1908).
*Kashmir.

Order TRICHOPTERA

Family RHYACOPHILIDAE

1. *Allagapetus punjabicus* Mart., RIM 38 (3) : 305 (1936). *Dalhousie: Punj Pull Nullah, 6500 ft.

2. *Apisilochorema indicum* Ulm., Ann. Soc. Entom. Belgique, 49 : 38, figs. 29-33, (1905).
*Dalhousie.

3. *Rhyacophila pallida* Mart., RIM, 37 (2) : 100 (1935).
*Dalhousie : Punj Pul Nullah, 6500 ft.

4. *Rhyacophila* sp., RIM, 37 (2) : 104 (1935).
*Dalhousie : near Punj Pul Nullah, 6500 ft., [U. P. : Kumaon Hills, Saraiya; Darjeeling Distt.]

Family PHILOPOTAMIDAE

5. *Dolophilodes indicus* Mart., RIM, 37 (2) : 122 (1935).
*Dalhousie : Punj Pul Nullah, 6500 ft.

Family STENOPSYCHIDAE

6. *Parastenopsyche similis* (Ulm.), Ent. Mitt., 16 : 175 (1927) (Stenopsyche); RIM, 37 (2) : 136 (1935).
*Dalhousie : Bakrota Hill 7000 ft., Kalatop Hill; Kangra Valley: Nagal Khud near Palampur.

7. *Stenopsyche griseipennis* Mc Lach., Trans. Ent. Soc. London. 3 (5) : 265 (1866); RIM, 37 (2) : 131 (1935).
*Kulu. [Sikkim; Kurseong; Darjeeling; Calcutta; Assam.]

Family PSYCHOMYIDAE

8. *Ecnomus montanus* Mosely, J. Taxon. Ent, 1 : 168, pl. 7 (1932); RIM 37 (2) : 139 (1935).
*Kashmir. [Kumaon : Bhimtal, 4450 ft., Ramgarh; Rewa : Harra.]

Family ARCTOPSYCHIDAE

9. *Arctopsyche lobata* Mart., Proc. Zoo. Soc. London, p. 77, figs. 20-21 (1930); RIM, 37 (2) : 170 (1935).
*Dalhousie : Punj Pul Nullah, 6500 ft.

Family POLYCENTROPIDAE

10. *Plectrocnemia obliquofasciata* Mart., RIM 37, (2) : 154 (1935).
*Dalhousie : Punj Pul Nullah, 6500 ft. [Darjeeling.]

11. *Plectrocnemia punjabica* Mart., RIM, 37 (2) : 152 (1935).
*Dalhousie : Punj Pul Nullah, 6500 ft.

Family SERICOSTOMATIDAE

12. *Agoerodes margula* Mosely, JBNHS, 48 (2) : 241 (1949).
*Kashmir : Gulmarg.

13. *Ashmira elica* Mosely, JBNHS, 41 (1) : 45 (1939).
*Kashmir : R. Arrah, Gulmarg.

14. *Brachycentrus kozlovi* Martinov, Ann. Mus. Zool. Ac. Sci. Perters., 14 : 291-4 (1909); JBNHS, 40 (3) : 495 (1938).
*Kashmir : L. Vishensar, 12000 ft. [W. Tibet : Basgo, Chushol, 14228 ft.]

15. *Dinarthrum inerme* McLach., Scient. Res. ii, Yarkand Mission, Neur., Calc., p. 5, figs. 1-4 (1878); JBNHS, 41 (2) : 336 (1939).
*Leh.

16. *Dinarthrum* (*Indodinarthrum*) *latum* Martinov, RIM, 38 (3) : 283 (1936); JBNHS, 42 (4) : 772 (1941).
*Dalhousie: Punj Pul Nullah, 6500 ft. [Darjeeling.]
17. *Dinarthrum nagana* Mosely, JBNHS, 41 (2) : 338 (1939).
*Kashmir : Nara Nag., 7500 ft.
18. *Dinarthrum parvulum* (McLach.), Fedtsch. Reise Turkestan, Neur., p. 33, pl. III, figs. 2 (1875); JBNHS, 41 (2) : 325 (1939).
*Kashmir.
19. *Dinarthrum* (*Indodinarthrum*) *punjabicum*, Martinov, RIM, 38 (3) : 282 (1936); JBNHS, 42 (4) : 772 (1941).
*Dalhousie : Punj Pul Nullah, 6500 ft.
20. *Dinarthrum rema* Mosely, JBNHS, 41 (2) : 337 (1939).
*Murree.
21. *Dinarthrum sonomax* Mosely, JBNHS, 41 (2) : 339 (1939).
*Kashmir : Sonamarg. [W. Tibet.]
22. *Eothremma hindustana* Martinov, RIM, 38 (3) : 296 (1936); JBNHS, 41 (1) : 40 (1939).
*Dalhousie : Punj Pul Nullah, 6500 ft.
23. *Eothremma laga* Mosely, JBNHS, 41 (1) : 41 (1939).
*Kashmir : Gagabal, 12000 ft.
24. *Eothremma punja* Mosely, JBNHS, 41 (1) : 41 (1939).
*Punjab : Chotah Bagahal tributary to R. Uhl.
25. *Micrasema punjaubi* Mosely, JBNHS, 40 (3) : 496 (1938).
*Punjab : R. Uhl, Chotah Bagahal.

Family PHRYGANEIDAE

26. *Eubasilissa mclachlani* White, Proc. Ent. Soc. London, p. 26 (1861); JBNHS, 38 : 126 (1935); RIM, 38 (3) : 303 (1936).
*Kulu. [Darjeeling, Shillong.]
27. *Eubasilissa regina* Malach., J. Linn. Soc. (Zool), 11 : 103; JBNHS, 38 : 125 (1935); Martinov, RIM, 38 : 303. (1936).
*Kulu. [China; Japan; Formosa.]

Family LIMOPHILIDAE

28. *Apatidea brevis* Mosley, JBNHS, 38 (3) : 447 (1936).
*Kashmir, Gagirbal, 5190 ft., Khilanmarg. 10,500 ft.
29. *Astenophylina kashmirus* Mosely, JBNHS, 38 : 473 (1936).
*Kashmir, R. Arrah.
30. *Colopotaulius major*, Martinov., Zool. Jahrb., 27 : 516-18, pl. 24, 1909; Mosely, JBNHS, 38 : 451 (1936).
*Kashmir. [Caucasus; Kamtshatka.]
31. *Micropterna indica* Mosely, JBNHS, 38 : 454 (1936).
*Kashmir, Khanabal, 5600 ft.
32. *Phylostenax himalus* Mosely, Entom., 48 : 184 (1935); RIM, 38 : 297 (1936).
*Dalhousie : Kalatop Hill. [Kumaon, Muktesar, 7000 ft; W. Himalayas; Darjeeling.]

33. *Pseudohalesus kaschmirus* Martinov, Ann. Mus. Zool. Acad. Sci. USSR, 28 : 481 (1927); JBNHS, 38 : 463 (1936).
*Kashmir. [Western Tibet; Charga.]
34. *Stenophyliella kashmirensis* Mosely, JBNHS, 38 : 472 (1936).
*Kashmir.
35. *Stenophylina mitchelli* Mosely, RIM, 38 : 298 (1936); JBNHS, 38 : 460 (1936).
*Kashmir Valley, 5000-6000 ft, Lake Vishensar 12,000 ft.
36. *Stenophylina schelfei* Kimmins, AMNH, 12 : 110 (1954).
*Kangra Distt., Kulu, Dibibokri Nal; Runi Thach.
37. *Trichophylax rotundipennis* Mosely, JBNHS, 38 : 462 (1936).
*Murree.

Order LEPIDOPTERA

Family HAPIALIDAE

1. *Hepialiscus nepalensis* Wlk., Wlk. Cat., 7 : 1557; Hampson, FBI, 1 : 317 (1892).
*Kulu. [Simla; Nepal; Sikkim.]

Family COSSIDAE

2. *Azygophleps albofasciata* Moore, Lep. Atk., p. 87; Hampson, FBI, 1 : 309 (1892).
*Kashmir. [Sikhim.]
3. *Cossus acronyctoides* Moore, PZS, p. 411 (1879), pl. xxxiv, fig. 4; Hampson, FBI, 1 : 305 (1892).
*Kashmir. [Ganjam; Bombay; Mhow; Nilgiris.]

Family ZYGAENIDAE

4. *Artona confusa* Butl., J. Linn. Soc. Zool., 12 : 357 ; Hampson, FBI, 1 : 236 (1892).
*N. W. Himalayas. [Sikkim.]
5. *Artona zebraica* Butl., J. Linn. Soc. Zool., 12: 356; Hampson, FBI, 1 : 265 (1892).
*Kulu; Mandi. [Sikhim; Nagas. Perak.]
6. *Chalcosia argentata* Moore, Lep. Atk. p. 17; Hampson, FBI, 1 : 265 (1892).
*N. W. Himalayas. [East Himalayas : Khasis.]
7. *Chalcosia idaeoides* Herr-Schaffer, Samml. ausser. Schmett., p. 78, pl. i, fig. 6; Hampson, FBI, 1 : 265 (1892).
8. *Lophosoma cupreum* Wlk., Wlk. Cat., 7 : 1596 ; Hampson, FBI, 1 : 237 (1892).
*Kulu. [Sikkim. Andamans.]
9. *Trypanophora semihyalina* Koll., Hugel's Kasch., 4 : 457; Hampson, FBI, 1 : 249 (1892).
*Kashmir; *Kangra. [Sikkim; Calcutta, E. Pagu. Hongkong.]

10. *Zygaena cashmirensis* Koll., Hugel's Kasch., 4 : 459, p. xix, fig. 6; Hampson, FBI, 1 : 230 (1892).
*Kashmir; *Kangra. [Nepal.]

Family PYRALIDAE

11. *Analyta singulalis* Guen., Delt. Pyr., p. 223; Hampson, FBI, 4: 369 (1896).
*Kulu. [Mhow. Borneo, Ambonia.]

12. *Aulacodes hamalis* Snell., Tijd. ent., 19 : 199, pl. viii, fig. 4 Hampson, FBI, 4 : 214 (1896).
*N. W. Himalayas. [Sikkim, Nilgiris.]

13. *Bostra vibicalis* Led., Wien. ent. Mon., 7 : 338, pl. vii, fig. 4 : Hampson, FBI, 4 : 176 (1896).
*N. W. Himalayas. [Bombay. Ceylon. Rangoon.]

14. *Cirrhochrista brizoalis* Wlk., Wlk. Cat., 19 : 976; Hampson, FBI, 4 : 50 (1896).
*N. W. Himalayas. [Japan, China, Formosa, Bombay, Nilgiris, Borneo.]

15. *Crambvs impurellus* Hampson, PZS, p. 938 (1895) FBI, 4 : 16 (1896).
*Kashmir. [Afganistan.]

16. *Crambus perlellus* Scop., Ent. Carn. 620 : 243; Hampson, FBI, 4 : 16 (1896).
*Kashmir. [Europe.]

17. *Cymoriza ustalis* Wlk., Wlk. Cat. 34 : 1529; Hampson, FBI, 4 : 201 (1896).
*Kulu; *Dharamsala. [Sikkim. Java.]

18. *Endotricha costaemaculatis* Christ., Bull. Soc. Nat. Mosc., 1 : 4 (1881); Hampson, FBI 4 : 133 (1896).
*Dalhousie. [Siberia, Japan, Sikkim.]

19. *Endctricha memesterialis* Wlk., Wlk. Cat., 17 : 285; Hampson, FBI, 4 : 133 (1896).
N. W. Himalayas. [Bombay. Nilgiris. Ceylon. Burma. Formosa.]

20. *Glyphodes crithealis* Wlk., Wlk. Cat., 17 : 334 : Hampson, FBI, 4 : 358 (1896).
N. W. Himalayas. [China.]

21. *Glyphodes hilaralis* Wlk., Wlk. Cat., 18 : 532; Hampson, FBI, 4 : 348 (1896).
N. W. Himalayas. [Ceylon; Rangoon; Borneo; Sumatra.]

22. *Herculia imbecilis* Moore, Lep. Ceyl., 3 : 264; Hampson, FBI, 4 : 160 (1896).
N. W. Himalayas. [Nilgiris; Ceylon; Java; Celebes.]

23. *Hypsophgia mauritialis* Boisd., Faun. Ent. Madag., Lep., p. 119 pl. 16, fig. 8; Hampson, FBI, 4 : 148 (1896).
N. W. Himalayas. [Madagascar; China; Burma; Manipur.]

24. *Lygropia obrinusalis* Wlk., Wlk. Cat., 18 : 549; Hampson, FBI, 4 : 341 (1896).
*Kulu. [Simla; Mhow; Nilgiris; Nicobar.]

25. *Lygropia poltisalis* Wlk., Wlk. Cat., 18 : 714; Hampsen, FBI, 4 : 344 (1896).
*Dalhousie; *Dharamsala. [Muree; Sikkim; Khasis; Borneo.]

26. *Nephopteryx bicolorella* Leech, Entom. p. 108, pl. v, fig. 5 (1889); Hampson, FBI, 4 : 79 (1896).
*Dalhousie. [Japan.]

27. *Macalla derogatella* Wlk., Wlk. Cat., 27 : 30; Hampson, FBI, 4 : 114 (1896).
*Dalhousie. [Simla; Murree; Nagas; Sikkim. Borneo.]

28. *Nephopteryx morosalis* Saalm., Ber. Sevek. Nat. Ges., p. 307 (1879. 80); Hampson, FBI, 4 : 82 (1896).
N. W. Himalayas. [W. & S. Africa; Madagascar; Amur.]

29. *Noctuelia fractilinealis* Ersch., Fedtschenko Reise Turk., Lep., p. 77, pl. v, fig. 82; Hampson, FBI, 4 : 445 (1896).
*Kashmir. [Persia; Turkestan.]

30. *Nacoleia tempiusalis* Wlk., Wlk. Cat. 18 : 704 Hampson, FBI, 4 : 318 (1896).
N. W. Himalayas. [Sikkim; Nilgiris. Borneo.]

31. *Patissa fulvosparsa* Butl., Trans. Ent. Soc. p. 591 (1881); Hampson, FBI, 4 : 44 (1896).
*Kulu; *Dharamsala. [Poona; Nilgiris. Java. Japan.]

32. *Phlyctaenodes massalis* Wlk., Wlk. Cat., 18 : 792; Hampson, FBI, 4 : 408 (1896).
N. W. Himalayas. [Punjab; Karachi; Poona; W. Africa; Ceylon;] Australia.

33. *Phlyctaenodes verticalis* Linn., Syst. Nat. p. 882; Hampson, FBI, 4 : 409 (1896).
N. W. Himalaya. [Khasis; Europe; Japan; Afganistan.]

34. *Phycita dorripunctella* Rag., Nouv. Gen., 22 ; Hampson, FBI, 4 : 97 (1896).
*Kashmir. [Punjab; Nilgiris; Ceylon.]

35. *Pionea forficalis* Linn., Syst. Nat., p. 882; Hampson, FBI, 4 : 425 (1896).
N. W. Himalayas. [Europe; Japan; Sikkim.]

36. *Polyocha leucocincta* Wlk., Wlk. Cat., 27 : 169; Hampson, FBI, 4 :62 (1896).
N. W. Himalayas. [Punjab; Assam; Borneo.]

37. *Polyocha umbricostella* Rag., Nouv. Gen., p. 38; Hampson, FBI, 5 : 62 (1896).
N. W. Himalayas. [Flores.]

38. *Polythlipta cerealis* Led., Wien. ent. Mon., p. 477 (1863); Hampson, FBI, 4 : 365 (1896).
*N. W. Himalayas. [Khasis.]

39. *Pyralis elongalis* Koll., Hugel's Kaschmir, 4 : 493; Hampson, FBI, 4 : 151 (1896).
N. W. Himalayas.

40. *Pyrausta aerealis* Hubn., Samml. eur. Schmett., Pyr. fig. 44; Hampson, FBI, 4 : 431 (1896).
*Kashmir. [Europe.]

41. *Pyrausta canotinctalis* Hampson, FBI, 4 : 431 (1896).
*Dalhousie; *Kulu.

42. *Pyrausta nubilalis* Hubn., Samml. eur. Schmett; Pyr., fig. 94; Hampson, FBI, 4 : 435 (1896).
N. W. Himalayas. [Europe; Sikkim; Khasi Manipur.]

43. *Pyrausta signatalis* Wlk., Wlk. Cat., 34 : 1444; Hampson, FBI, 4 : 438 (1896).
N. W. Himalayas. [Nilgiris; Ceylon; Java.]

44. *Pyrausta sanguinalis* Linn., Syst. Nat., i (2); 882; Hampson, FBI, 4 : 432 (1896).
*Kulu. [Europe; Syria; Simla.]

45. *Pyrausta vitellinalis* Koll. Hugel's Kaschmir, 4 : 492; Hampson, FBI, 4 : 437 (1896).
*Kashmir. [Sikkim; Rangoon.]

46. *Scirpophaga excerptalis* Wlk., Wlk. Cat. 27 : 142; Hampson, FBI, 4 : 446 (1896).
N. W. Himalayas. [Borneo; China.]

47. *Stericta aglossalis* Warr., ANMH (6) 17 : 456; Hampson, FBI, 4 : 123, (1896).
*Dalhousie. [Khasis.]

48. *Stericta haraldusalis* Wlk., Wlk. Cat. 16 : 160; Hampson, FBI, 4 : 121 (1896).
*Dharamsala; *Kulu. [Simla; Sikkim; Tenasserim; Amur; Japan.]

49. *Sylepta quadrimaculalis* Koll., Hugel's Kaschm. 4 : 492; Hampson, FBI, 4 : 336 (1896).
N. W. Himalayas. [Khasis; Sikkim; Borneo; Japan.]

50. *Sylepta seinisalis* Wlk., Wlk. Cat., 18 : 648; Hampson, FBI, 4 : 331 (1896).
N. W. Himalayas. [Sikkim; Khasis; Moulmein.]

51. *Sylepta verecunda* Warr., ANMH (6) 18 : 167; Hampson, FBI, 4 : 333 (1896).
N. W. Himalayas. [Sikkim; Khasis; Nilgiris; Ceylon.]

52. *Syngamia falsidicalis* Wlk., Wlk. Cat., 17 : 370; Hampson, FBI, 4 : 280 (1896).
N. W. Himalayas. [Khais; Nilgiris; Ceylon.]

53. *Tamraca torridalis* Led., Wien. ent. Mon., 7 : 342, 457, pl. 6, fig. 15; Hampson, FBI, 4 : 159 (1896).
N. W. Himalayas. [Bombay; Ceylon; Nagas. China; Burma; Ceylon.]

54. *Tegostoma comparale* Hubn., Samml. eur. Schmett., Pyr., fig. 126; Hampson, FBI, 4 : 444 (1896).
N. W. Himalayas. [Poona; Coimbatore.]

55. *Tegulifera faviusalis* Wlk., Wlk. Cat., 19 : 907; Hampson, FBI, 4 : 152 (1896).
N. W. Himalayas. [Sikkim; Assam; Nagas; Borneo.]

Family ARCTIIDAE

56. *Alphae leopardina* Koll., Hugel's Kaschm., 4 : 467, pl. 21, fig. 2; Hampson, FBI, 2 : 22 (1894).
N. W. Himalayas. [Khasi Hills.]

57. *Alphaea pannosa* Moore, PZS, p. 397, pl. 32, fig. 8 (1876); Hampson, FBI, 2 : 23, (1894).
N. W. Himalayas.

58. *Alphaea quadriramosa* Koll., Hugel's Kaschm., 4 : 468; Hampson, FBI, 2 : 21 (1894).
N. W. Himalayas. [Khasi Hills; Naga Hills.]

59. *Arctia orientalis* Moore, ANMH, 5 (1) : 230 (1878); Hampson, FBI, 2 : 16 (1894).
N. W. Himalayas. [Khasis; Sibsagar.]

60. *Arctia perornata* Moore, PZS, p. 395. pl. 32, fig. 2 (1879); Hampson, FBI, 2 : 16 (1894).
*Kashmir.

61. *Arctia suttadra* Moore, PZS, p. 395 (1879); Hampson, FBI, 2 : 16 (1894).
N. W. Himalayas.

62. *Arctia tibitica* Feld., Reis. Nov., pl. 101, fig. 12; Hampson, FBI, 2 : 17 (1894).
*Ladak.

63. *Areas imperialis* Koll., Hugel's Kaschm., 4 : 466, pl. 21, fig. 1; Hampson, FBI, 2 : 25 (1894).
N. W. Himalayas. [Sikkim.]

64. *Callimorpha lichenigera* Feld., Reis. Nov., pl. 101, fig. 3; Hampson, FBI, 2 : 36 (1894).
*Ladak.

65. *Callimorpha plagiata* Wlk., Wlk. Cat., 3 : 655; Hampson, FBI, 2 : 36 (1894).
N. W. Himalayas. [E. Himalayas; Yunnan; Assam.]

66. *Callimorpha principalis* Koll., Hugel's Kaschm., 4 : 465, pl. 20 fig. 2; Hampson, FBI, 2 : 35 (1894).
*Kashmir. [Sikhim; Burma.]

67. *Chrysorabdia bivitta* Wlk., Wlk. Cat., 7 : 1682; Hampson, FBI, 2 : 74 (1894).
N. W. Himalayas. [Manipur; Sikkim; Burma.]

68. *Creatonotus emittens* Wlk., Wlk. Cat., 3 : 638; Hampson, FBI, 2 : 28 (1894).
N. W. Himalayas. [Nepal; Manipur; S. India; Ceylon.]

69. *Cyna rama* Moore, Lep., E. I. Co. p. 306, pl. 62; Hampson, FBI, 2 : 62 (1894).
*Kulu. [Sikkim; Khasis.]

70. *Cyna candida* Feld., Reis. Nov., pl. 106, fig. 17; Hampson, FBI, 2 : 58 (1894).
N. W. Himalayas. [Sikkim.]

71. *Cyana gazella* Moore, PZS, p. 572, pl. 33, fig. 4, 1872; Hampson, FBI, 2 : 61 (1894).
N. W. Himalayas. [Sikkim.]

72. *Cyana guttifera* Wlk. Wlk. Cat., 7 : 1779; Hampson, FBI, 2 : 59 (1894).
N. W. Himalayas. [Sikkim; Nagas; Khandala; Andamans;]

73. *Cyana signa* Wlk., Wlk. Cat., 2 : 550; Hampson, FBI, 2 : 58 (1894).
*Kulu. Kulu to Sikkim; [Khasis; Burma.]

74. *Gnophria postfusca* Hampson, FBI, 2 : 70 (1894).
N. W. Himalayas.

75. *Gnophria rufifrons* Moore, PZS, p. 10, pl. 1, fig. 12 (1878); Hampson, FBI, 2 : 70 (1894).
N. W. Himalayas. [Sikkim.]

76. *Lithosia auriflua* Moore, PZS, p. 18, pl. 2, fig. 7 (1878); Hampson, FBI, 2 : 81 (1894).
*Kulu. [Manipur.]

77. *Lithosia calamaria* Moore, PZS, p. 18, (1878); Hampson, FBI, 2 : 7 : 79 (1894).
N. W. Himalayas. [Sikkim.]

78. *Lithosia vaegesa* Moore, Lep. E.I. Co., p. 304; Hampson, FBI, 2 : 85 (1894).
N. W. Himalayas. [Nepal; Sikhim; Khasis.]

79. *Macrolerochis pallens* Hampson, FBI, 2 : 66 (1894).
*Dalhousie. [Simla.]

80. *Macrolerochis parasena* Moore, Lep. E.I. Co., p. 299, p. 7a, fig. 6; Hampson, FBI, 2 : 66 (1894).
*Dalhousie; *Dharamsala. [Sikkim; Naga Hills.]

81. *Miltochrista dharma* Moore, PZS, p. 394. (1879); Hampson, FBI, 2 : 113 (1894).
*N. W. Himalayas. [Naga & Karen Hills.]

82. *Miltochrista influmata* Feld., Reis. Nov., pl. 106, fig. 16; Hampson, FBI, 2 : 113 (1894).
N. W. Himalayas.

83. *Ocnogyna postflavida* Hampson, FBI, 2 : 18 (1894).
*Kashmir [Skoro La]

84. *Rhynchopalpus argentalis* Moore, PZS, p. 89 (1867); Hampson, FBI, 2: 143 (1894).
N. W. Himalayas. [Sikkim.]

85. *Rhynchopalpus dentatus* Hampson, FBI, 2 : 143 (1894).
*Dalhousie.

86. *Sidyma albifimis* Wlk., Wlk. Cat., 7 : 1686; Hampson, FBI, 2 : 67 (1894).
N. W. Himalayas.

87. *Spilosoma comma* Wlk., Wlk. Cat., 7 : 1703; Hampson, FBI, 2 : 10 (1894).
N. W. Himalayas.

88. *Spilosoma erythrozona* Koll., Hungel's Kaschm., 4 : 468; Hampson, FBI, 2 : 11 (1894).
N. W. Himalayas, *Kashmir.

89. *Spilosoma multiguttatum* Wlk., Wlk. Cat., 3 : 657; Hampson, FBI, 2 : 3 (1894).
*Kulu. [Nepal; Sikkim;]

90. *Thyrgorina melanosoma* Hampson, FBI, 2 : 15 (1894).
*Kulu. [Sikkim; Khasis.]

91. *Thyrgorina rhodophila* Wlk., Wlk. Cat., 31 : 294; Hampson, FBI, 2 : 15 (1894).
N. W. Himalayas. [Sikkim; Nagas; Manipur.]

Family NOCTUIDAE

92. *Acantholipes siddimilis* Moore, Lep. Atk., p. 174; Hampson, FBI, 2 : 522 (1894).
N. W. Himalayas.

93. *Acronycta aceris* Linn., Syst. Nat., i, 2 : 846; Hampson, FBI, 2 : 241 (1894).
*Kashmir [Europe; Gurais Valley]

94. *Acronycta auaedina* Butl., Trans. Ent. Soc., p. 19 (1881); Hampson, FBI, 2 : 240 (1894).
N. W. Himalayas. [Punjab; Rangoon.]

95. *Acronycta bicolor* Moore, PZS, p. 332 (1881); Hampson, FBI, 2 : 243 (1894)
N. W. Himalayas.

96. *Acronycta paucinotata* Hampson, FBI, 2 : 240 (1894).
N. W. *Kashmir.

97. *Agrotis aecipter* Feld., Reis. Nov., pl. 3 fig. 29; Hampson, FBI, 2 : 189 (1894).
*Ladak. [Pangi; Sikkim.]

98. *Agrotis biconica* Koll., Hugel's Kaschm., 4 : 480; Hampson, FBI, 2 : 182 (1894).
N. W. Himalayas. [S. Africa; Punjab; Sikkim.]

99. *Agrotis c-nigrum* Linn., Syst. Nat., p. 852; Hampson, FBI, 2 : 188 (1894).
N. W. Himalayas. [Bombay, Ceylon; Nilgiris; Khasis; Europe; Japan; N. America.]

100. *Agrotis corticea* Schiff., Wien. Verz., 81 : 13; Hampson, FBI, 2 : 181 (1894).
N. W. Himalayas. [Sikkim; Nagas; Nilgiris; Madagascar.]

101. *Agrotis descripta* Brem., Lep. Ost.-Sib., p. 51, pl. iv, fig. 11 (1864); Hampson, FBI, 2 : 184(1894).
N. W. Himalayas. [Japan; Sikkim; Nilgiris.]

102. *Agrotis ditrapezium* Borkh., Schmett. Eur., 4 : 515; Hampson, FBI, 2 : 188 (1894).
N. W. Himalayas.

103. *Agrotis flammatra* Fabr., Mant. Ins., 2 : 155; Hampson, FBI, 2 : 189 (1894).
N. W. Himalayas. [Punjab; Sikkim; Europe.]

104. *Agrotis griseivena* Hampson, FBI, 2 : 187 (1894).
*Dalhousie.

105. *Agrotis junctura* Moore, PZS, p. 351 (1881); Hampson, FBI, 2 : 189 (1894)
*Dalhousie.

106. *Agrotis renalis* Moore, PZS, p. 341 (1881); Hampson, FBI, 2 : 187 (1894).
N. W. Himalayas. [Punjab; Sind.]

107. *Agrotis tenuis* Butl., Ill. Het., 7 : 57, pl. 127, fig. 12; Hampson, FBI, 2 : 184 (1894).
N. W. Himalayas, Laka; *Kangra.

108. *Agrotis triangularis* Moore, PZS, p. 55 (1867); Hampson, FBI, 2 : 189 (1894).
N. W. Himalayas. [Sikkim; Satara; Nilgiris; Japan.]

109. *Amphipyra magna* Wlk., Wlk. Cat., 33 : 868; Hampson, FBI, 2 : 191 (1894).
N. W. Himalayas. [Punjab.]

110. *Anisoneura hypocyanea* Guen., Noct., 3 : 162; Hampson, FBI, 2 : 456 (1894).
N. W. Himalayas. [Sikkim; Assam.]

111. *Arcte polygrapha* Koll., Hugels Kaschm., 4 : 478; Hampson, FBI, 2 : 487 (1894).
*Kashmir. [Simla; Sikkim.]

112. *Bombycia lecucocera* Hampson, FBI, 2 : 207 (1894).
*Kashmir. [Sind Valley.]

113. *Bravipecten captatus* Butl., Ill. Het., 7 : 79, pl. 133, fig. 1 Hampson, FBI, 2 : 361. (1894).
N. W. Himalayas. [Nilgiris; China.]

114. *Bryophila literata* Moore, PZS, p. 331 (1881); Hampson, FBI, 2 : 297 (1894).
N. W. Himalayas.

115. *Bryophila virescens* Hampson, FBI, 2 : 297 (1894).
*Dalhousie.

116. *Callopistria minuta* Butl., Ill. Het., 7 : 70, pl. 130, fig. 4; Hampson, FBI, 2 : 254 (1894).
N. W. Himalayas.

117. *Callopistria repleta* Wlk., Wlk. Cat., 7 : 865; Hampson, FBI, 2 : 255 (1894.)
N. W. Himalayas. [Japan.]

118. *Callopistria rivularis* Wlk., Wlk. Cat., 7 : 867; Hampson, FBI, 2 : 255 (1894).
N. W. Himalayas. [Nilgiris; Ceylon.]

119. *Calpe ophideroides* Guen., Noct., 2 : 374; Hampson, FBI, 2 : 564 (1894).
N. W. Himalayas. [Nepal; Singapore.]

120. *Caradrina divisa* Moore, Lep. Atk., p. 123; Hampson, FBI, 2 : 265 (1894).
N. W. Himalayas. [Sikkim.]

121. *Caradrina kadenii* Freyer, Beitr. Schmett., 2 : 247, pl. 186 (1836); Hampson, FBI, 2 : 260 (1894).
N. W. Himalayas. [Umballa.]

122. *Caradrina lineosa* Moore, PZS, p. 349 (1881); Hampson, FNI, 2 : 265. (1894).
*Kulu. [Japan; Punjab.]

123. *Catocala concubia* Wlk., Wlk. Cat., 13 : 1210; Hampson, FBI, 2 : 442 (1894).
N. W. Himalayas.

124 *Catocala distorta* Butl., Ill. Het., 7 : 77, pl. 132, fig. 4 ; Hampson, FBI, 2: 441 (1894).
*Kulu.

125. *Catocala nymphaea* Esp., Schmett. Eur., pl. 105, fig. 4; Hampson FBI, 2 : 440 (1894).
N. W. Himalayas. [Sikkim; Europe; N. America.]

126. *Calocala patala* Feld., Reis. Nov., pl. 112, fig. 23; Hampson, FBI, 2 : 439 (1894).
N. W. Himalayas.

127. *Chariclea artaxoides* Moore, PZS, p. 366, (1881); Hampson, FBI, 2 : 179 (1894).
N. W. Himalayas: [Manipur; Bombay.]

128. *Chariclea beatris* Moore, PZS, p. 365 (1881); Hampson, FBI, 2 : 178 (1894).
*N. W. Himalayas. [Mhow; Canara; Nilgiris; Baluchistan.]

129. *Chariclea irrorata* Moore, PZS, p. 364 (1881); Hampson, FBI, 2 : 179 (1894).
N.W . Himalayas. [Sikkim.]

130. *Chariclea marginalis* Wlk., Wlk. Cat., 12 : 830; Hampson, FBI, 2 : 177 (1894).
*N. W. Himalayas. [Sikkim; Bombay; Calcutta; Ganjam.]

131. *Churia ocellata* Butl., Ill. Het., 7 : 72, pl. 131, fig. 4; Hampson, FBI, 2 : 418 (1894).
N. W. Himalayas. [Nagas.]

132. *Cuculia albescens* Moore, PZS, p. 357 (1881); Hampson, FBI, 2 : 238 (1894).
*N. W. Himalayas. [Sikkim.]

133. *Cuculia brevipennis* Hampson, FBI, 2 : 239 (1894).
*N. W. Himalayas. [Sikkim, Nagas.]

134. *Cuculia pullata* Moore, PZS, p. 358 (1881); Hampson, FBI, 2 : 239 (1894).
*Dalhousie. [Sikkim.]

135 . *Cosmia affinis* Linn., Syst. Nat., 12 : 838; Hampson, FBI, 2 : 321 (1894).
*Kashmir. [Europe; Japan; Gurais Valley.]

136. *Dichromia quadralis* Wlk., Wlk. Cat., 16 : 14; Hampson, FBI, 3 : 73 (1895).
*Dalhousie; *Dharamsala. [Sikkim; Khasis; Rangoon.]

137 . *Dipterygia indica* Wlk., Wlk. Cat., 32 : 647; Hampson, FBI, 2 : 236 (1894).
*N. W. Himalayas.

138. *Diphthera vigens* Wlk., Wlk. Cat., 32 : 616; Hampson, FBI, 2 : 294 (1894).
*Kulu. [Sikkim; Nagas.]

139. *Eublemma roseana* Moore, PZS, p. 370 (1881); Hampson, FBI, 2 : 340 (1894).
N. W. Himalayas. [Sikkim; S. India.]

140. *Euplexia confecta* Wlk., Wlk. Cat., 15 : 1705; Hampson, FBI, 2 : 219 (1894).
N. W. Himalayas.

141. *Euplexia adjuncta* Moore, PZS, p. 357 (1881); Hampson, FBI, 2 : 209 (1894).
*Dalhousie.

142. *Euplexia heterocampoides* Hampson, FBI, 2 : 221 (1894).
*Kulu. [Sikkim.]

143. *Euplexia indistans* Guen., Noct., 2 : 87; Hampson, FBI, 2 : 208 (1894).
N. W. Himalayas. [Bombay, S. India.]

144. *Euplexia niveiplaga* Wlk., Wlk. Cat., 6 : 593; Hampson, FBI, 2 : 208 (1894).
N. W. Himalayas. [Sikkim; Nilgiris.]

145. *Euplexia pulcherrima* Moore, PZS, p. 54, 1867; Hampson, FBI, 2 : 219 (1894).
N. W. Himalayas. [Sikkim; Nilgiris.]

146. *Euplexia semifascia* Wlk., Wlk. Cat., 33 : 737; Hampson, FBI, 2 : 212 (1894).
N. W. Himalayas. [Satara; Nilgiris.]

147. *Euplexia stoliczkae* Feld., Reise Nov. pl. 109, fig. 32; Hampson, FBI, 2 : 214 (1894).
*Dalhousie. [Thandiani; Punjab.]

148. *Eurois chalybeata* Wlk., Wlk. Cat., 32 : 665; Hampson, FBI, 2 : 230 (1894).
*Kulu. [Sikkim; Khasis.]

149. *Eurois griseimagrinata* Hampson, FBI, 2 : 229 (1894).
*Dalhousie.

150. *Eurois involuta* Wlk., Wlk. Cat., 9 : 201; Hampson, FBI, 2 : 230 (1894).
N. W. Himalayas.

151. *Eurois luteifrons* Wlk., Wlk. Cat., 2 : 751; Hampson, FBI, 227 (1894).
*Kashmir. [Khasis.]

152. *Euscotia inextricata* Moore, PZS, p. 342, (1881); Hampson, FBI, 2 : 237 (1894).
*N. W. Himalayas. [Nilgiris.]

153. *Eutelia excitans* Bult., PZS, p. 381 (1886); Hampson, FBI, 2 : 395 (1894).
*N. W. Himalayas.

154. *Eutelia maculata* Butl., Ill. Het., 7 : 71, pl. 130, fig. 5; Hampson, FBI, 2 : 393 (1894).
N. W. Himalayas.

155. *Fodina pallula* Guen., Noct., 3 : 275; Hampson, FBI, 2 : 530 (1894).
*N. W. Himalayas. [Calcutta; Assam; Ceylon.]

156. *Fodina stola* Guen., Noct., 3 : 275; Hampson, FBI, 2 : 530 (1894).
*N. W. Himalayas. [Sikkim; Bhutan; Ceylon.]

157. *Hadena brassicae* Linn., Syst. Nat., p. 852; Hampson, FBI, 2 : 202 (1894).
N. W. Himalayas. [Punjab; Europe.]

158. *Hadena costigera* Moore, PZS, p. 350 (1881); Hampson, FBI, 2 : 200 (1894).
*N. W. Himalayas. [Khasis.]

159. *Hadena culla* Moore, PZS, p. 347 (1881); Hampson, FBI, 2 : 204 (1894).
*Dalhousie.

160. *Hadena ferrisparsa* Hampson, FBI, 2 : 201 (1894).
*Dalhousie. [Simla].

161. *Hadena perdentata* Hampson, FBI, 2 : 198 (1894).
*Kashmir.

162. *Hadena poliostigma* Hampson, FBI, 2 : 201 (1894).
*Kashmir. [Sind Valley.]

163. *Hadena scotochlora* Koll., Hugel's Kaschm., 4 : 482 ; Hampson, FBI, 2 : 203 (1894).
*Kashmir. [Punjab; Thandiani.]

164. *Hadena simitlima* Moore, PSZ, p. 344 (1881); Hampson, FBI, 2 : 201 (1894).
*N. W. Himalayas. [Sikkim.]

165. *Heliothis nubigera* Herr-Schaffer, Eur. Schmett., 2 : 366; Hampson, FBI, 2 : 175 (1894).
*Dalhousie. [Cutch; Syria; Europe; Somaliland.]

166. *Heliothis scutosa* Schiff., Wien. Verz., 89 : 1 ; Hampson, FBI, 2 : 175 (1894).
*N. W. Himalayas. [Europe; China.]

167. *Heliothis translucens* Feld., Reis. Nov., pl. 108, fig. 49; Hampson, FBI, 2 : 176 (1894).
*N. W. Himalayas. [Urni.]

168. *Hermonassa consignata* Wlk., Wlk. Cat., 32 : 632; Hampson, FBI, 2 : 196 (1894).
*Kashmir; *Dharamsala. [Sikkim.]

169. *Hyela obliqua* Moore, Lep. Atk., p. 143; Hampson, FBI, 2 : 307 (1894).
*Kashmir; *Dharamsala. [Simla.]

170. *Hyelopsis plumbata* Butl., Ills. Het., 7 : 61, pl. 129, fig. 4; Hampson, FBI, 2 : 305 (1894).
*N. W. Himalayas. [Nilgiris.]

171. *Hylodes caranea* Cram., Pap. Exot., 3; pl. 269; Hampson, FBI, 2 : 462 (1894).
N. W. Himalayas. [Assam; Calcutta; Burma; Perak.]

172. *Hypena masurialis* Guen., Delt. et. Pyr., p. 38; Hampson, FBI, 3 : 79 (1895).
*Kashmir. [India; Burma; Ceylon; Australia; E. Africa.]

173. *Hypena narratalis* Wlk., Wlk. Cat., 16 : 57; Hampson, FBI, 3 : 81 (1095).
*N. W. Himalayas.

174. *Hypena proboscidalis* Linn., Syst. Nat. 1 (2) : 881; Hampson, FBI, 77 (1895).
*Kulu. [Sikkim; Khasis; Europe; Japan.]

175. *Hypena rectivattalis* Moore, PZS., p. 84 (1867); Hampson, FBI, 3 : 81 (1895).
*N. W. Himalayas. [Punjab; Bombay; Nilgiris; Africa; Japan.]

176. *Hypena thermesialis* Wlk., Wlk. Cat., 34 : 1515; Hampson, FBI, 3 : 90 (1895).

*N. W. Himalayas. [Bombay; Nilgiris; Ceylon; Java; China.]

177. *Hypena uniformis* Hamlson, Ill. Het; 8 : 96, pl. 148, fig. 7; FBI, 3 : 87 (1895).
*Dalhousie. [Nilgiris; Khaisis; China.]

178. *Hypocala moorei* Butl., ANMH (6) 10 : 21 (1892); Hampson, FBI, 2 : 454 : (1894).
*N. W. Himalayas. [Sikkim; Canacra; Ceylon; W. Africa.].

179. *Hypocala subsatura* Guen., Noct., 3 : 75 ; Hampson, FBI, 2: 45 3 (1894).
*N. W. Himalayas. [Sylhet.]

180. *Leucania angulifera* Moore, PZS, p. 333 (1881); Hampson, FBI, 2 : 276 (1894).
N. W. Himalayas.

181. *Leucania nainica* Moore, PZS, p. 337 (1881); Hampson, FBI, 2 : 274 (1894).
N. W. Himalayas. [Khasis.]

182. *Leucania nigrofasciata* Hampson, FBI, 2 : 279 (1894).
*Kulu.

183. *Leucania subsignata* Moore, PZS, p. 336(1881);Hampson, FBI, 2: 272(1894).
N. W. Himalayas. [Poona].

184. *Mecodina cineratia* Butl., Ill. Het., 3 : 27, pl. 47, fig. 4; Hampson, FBI, 3 : 3 (1895).
*N. W. Himalayas. [Khasis; Sikkim; Japan.]

185. *Megalodes kashmirensis* Hampson, FBI, 2 : 309 (1894).
*Gulmarg, Kashmir.

186. *Melipotis cashmirensis* Hampson, FBI, 2 : 478 (1894).
*Kashmir.

187. *Metachrostis conspersa* Butl., PZS, p. 673 (1880); Hampson, FBI, 2 : 327 (1894).
*Kulu. [Formosa.]

188. *Metachrostis quinaria* Moore, PZS, p. 371 (1881); Hampson FBI, 2 : 326 (1894).
*N. W. Himalayas. Punjab [Karachi; Mhow.]

189. *Moma champa* Moore, PZS., p. 403 (1879); Hampson, FBI, 2: 435 (1894).
N. W. Himalayas. [Punjab; Nilgiris; Ceylon].

190. *Nodaria erecta* Moore, Lep. Atk., p. 193; Hampson, FBI, 3 : 57 (1895).
*N. W. Himalayas. [Sikkim; E. Pegu.]

191. *Nonagria fuscoverens* Hampson, FBI, 2 : 285 (1894).
*Kashmir.

192. *Nyctipao albicincta* Koll., Hugel's Kaschm., 4 : 474, pl. 22 (1844); Hampson, FBI, 2 : 461 (1894).
*N. W. Himalayas. [Sikkim; Khasis; Shillong; Nilgiris].

193. *Nyctipao glaucopis* Wlk., Wlk. Cat., 14 : 1306; Hampson, FBI, 2 : 461 (1894).
*N. W. Himalayas. [Sikkim; Khasis.]

194. *Ophiusa conficiens* Wlk., Wlk. Cat., 14 : 1432; Hampson, FBI, 2 : 501 (1894).
*N. W. Himalayas. [Bombay.]

195. *Ophiusa cuprea* Moore, PZS, p. 74 (1867); Hampson, FBI, 2 : 497 (1894).
*N. W. Himalayas. [Bengal; Central India.]

196. *Panilla dispila* Wlk., Wlk. Cat., 33 : 890; Hampson, FBI, 2 : 476 (1894).
*N. W. Himalayas. [Poona; Nilgiris.]

197. *Plusia hetetata* Butl., Ill. Het., 7 : 71, pl. 131, fig. 1 ; Hampson, FBI, 2 : 574 (1894).
*Kulu. [Japan.]

198. *Plusia limbirena* Guen., Noct., 2 : 350 ; Hampson, FBI, 2 : 568 (1894).
N. W. Himalayas. [Sikkim; Nilgiris.]

199. *Plusia modesta* Hubn., Bietr., 1 : 1 pl. 1, fig. 1a; Hampson, FBI, 2 : 575 (1894).
*Kulu; *Kashmir. [Europe.]

200. *Plusia tetragona* Wlk., Wlk. Cat., 12 : 932; Hampson, FBI, 2 : 574 (1894).
*Kulu; *Dharamsala. [Japan.]

201. *Polia transversa* Moore, Lep., Atk., 125 ; Hampson, FBI, 2 : 232 (1894).
*Kashmir. [Thandiani; Punjab.]

202. *Polia virescens* Hampson, FBI, 2 : 234 (1894).
*Kashmir.

203. *Polydesma otiosa* Guen., Noct., 2 : 442; Hampson, FBI, 2 : 468 (1894).
*N. W. Himalayas. [Sylhet; Nilgiris.]

204. *Polydesma sublimis* Feld., Reis. Nov., pl. 3, fig. 23; Hampson, FBI, 2 : 466 (1894).
*N. W. Himalayas. [Sikkim.]

205. *Pyrrhia umbra* Hubn., Berl. Nag., 3 : 394; Hampson, FBI, 2 : 172 (1894).
*N. W. Himalayas. [Amur; Nagas; Europe; Japan.]

206. *Raparna digramma* Wlk., Wlk. Cat., 34 : 1170; Hampson, FBI, 3 : 24 (1895).
*N. W. Himalayas. [India, Ceylon.]

207. *Remigia discios* Koll., Hugel's Kaschm., 4 : 477; Hampson, FBI, 2 : 525 (1894).
*N. W. Himalayas.

208. *Rhynchina angulata* Wlk., Trans. ent., Soc. (3) 1 : 88; Hampson, FBI, 3: 75 (1895).
*N. W. Himalayas. [Nilgiris.]

209. *Rhynchina sigillata* Butl., Ill. Het., 7 : 75, pl. 131, fig. 11; Hampson, FBI, 3 : 76 (1895).
*Dalhousie; *Dharamsala.

210. *Semiophora sastaneipennis* Hampson, FBI, 2 : 206 (1894).
*Kashmir.

211. *Semiophora ferrosticta* Hampson, FBI, 2 : 205 (1894).
*Kashmir.

212. *Semiophora orthosioides* Butl., Ill. Het., 7 : 56, pl. 128, fig. 1; Hampson, FBI, 2 : 205 (1894).
*N. W. Himalayas; *Mandi.

213. *Simplicia butesalis* Wlk., Wlk. Cat., 16 : 187; Hampson, FBI, 3 : 36 (1895).
*N. W. Himalayas. [Sikkim; Nilgiris; Ceylon, S. Africa.]

214. *Simplicia niphora* Butl., Ill. Het., 2 : 56, pl. 38, fig. 9; Hampson, FBI, 3 : 36 (1895).
*N. W. Himalayas. [Sikkim.]

215. *Spiredonia alix* Guen., Noct., 3 : 171; Hampson, FBI, 2′: 458 (1894).
N. W. Himalayas. [Assam; Andamans; Nicobars; Java.]

216. *Stictoptera albodentata* Moore, Lep. Atk., 165; Hampson, FBI, 2 : 403 (1894).
*N. W. Himalayas. [Sikhim; Khasis; E. Pegu.]

217. *Stictoptera costata* Moore, Lep. Ceyl., 3 : 123, pl. 159, fig. 8; Hampson, FBI, 2 : 403 (1894).
*N. W. Himalayas. [Ceylon.]

218. *Sypna costellata* Moore, PZS, 1883, p. 24; Hampson, FBI, 2 : 447 (1894).
*N. W. Himalayas.

219. *Sypna curvilinea* Moore, PZS, p. 69, p. 6, fig. 4 (1867) Hampson, FBI, 2 : 449 (1894).
*N. W. Himalayas. [Sikkim.]

220. *Sympna cyanivitta* Moore, PZS, p. 70 (1867); Hampson, FBI, 2 : 448 (1894).
*N. W. Himalayas. [Sikkim.]

221. *Sypna omicrinigera* Guen., Noct., 3 : 145; Hampson, FBI, 2 : 446 (1894).
*N. W. Himalayas. [Sikkim; Assam.]

222. *Sypna pannosa* Moore, Lep. Atk., 168, pl. 5, fig. 12; Hampson, FBI, 2 : 451 (1894).
*N. W. Himalayas. [Khasias.]

223. *Sypna punctosa* Wlk., Wlk. Cat., 33 : 939; Hampson, FBI, 2 : 447 (1894).
*N. W. Himalayas. [Sikkim; Shillong; Nilgiris; Travancore.]

224. *Tarache fascialis* Hampson, FBI, 315 (1894).
*Kashmir. [Sind, Gurias Valley.]

225. *Toxocampa dorsigera* Wlk., Wlk. Cat., 33 : 873; Hampson, FBI, 2 : 346 (1894).
*N. W. Himalayas. [Nilgiris; Ceylon.]

226. *Trisuloides caerulea* Butl., Ill. Het., 7 : 35, pl. 128, fig. 3; Hampson, FBI, 2 : 437 (1894).
*N. W. Himalayas.

227. *Trisuloides infausta* Wlk., Wlk. Cat., 9 : 237; Hampson, FBI, 2 : 436 (1894).
*N. W. Himalayas. [Sikkim; Sylhet; Shillong.]

228. *Xanthia albosignata* Moore, PZS, 1881 : 355; Hampson, FBI, 2 : 170 (1894).
*N. W. Himalayas.

229. *Xanthia gilbago* Esp., Schmett. Eur., p. 176, fig. 2; Hampson, FBI, 2 : 171 (1894).
*Kashmir. [Gurias Valley; Europe.]

230. *Xanthoptera nigripalpis* Wlk., Wlk. Cat., 35 : 1965; Hampson, FBI, 2 : 318 (1894).
*N. W. Himalayas. [Ceylon.]

231. *Zagira reticulata* Moore, Lep. Atk., p. 178, pl. vi, fig. 9; Hampson ,FBI, 2 : 346 (1894).
*Dalhousie. [Sikkim.]

Family NOTODONTIDAE

232. *Anticyra combusta* Wlk., Wlk. Cat. 5 : 1092; Hampson, FBI, 1 : 145 (1892).
*N. W. Himalayas. [Karachi; Poona; Java; Philippines].

233. *Ichthyura undulata* Hampson, Ill. Het. 7 : 60; FBI, 1 : 174;
*N. W. Himalayas. [Nilgiris.]

234. *Nadata niveiceps* Wlk., Wlk. Cat., 32 : 554; Hampson, FBI, 1 : 130 (1892).
*N. W. Himalayas.

235. *Notodonta gigantea* Elves, PZS, p. 399, (1890); Hampson, FBI, 1 : 162 (1892).
*Kulu. [Sikkim.]

236. *Pydna euptagia* Hampson, FBI, 1 : 141 (1892).
*N. W. Himalayas. [Sikkim.].

237. *Stauropus albivertex* Hampson, FBI, 1 : 152 (1892).
*Kashmir. [Gurias Valley.]

238. *Stauropus fasciatus* Moore, Lep. Atk., 58; Hampson, FBI, 1 : 152 (1892).
*Dalhousie. [Sikhim; Khandla; Andamans.]

Family LYMANTRIIDAE

239. *Aroa cinnamomea* Moore, Lep. Atk., p. 44; Hampson, FBI, 1 : 439 (1892).
*N. W. Himalayas. [Attock, Punjab.]

240. *Aroa pyrrhochroma* Wlk., Wlk. Cat., 32 : 329; Hampson, FBI, 1 : 439 (1892).
*N. W. Himalayas. [Sikkim; Khasis; Nagas; Bombay.]

241. *Dasychira inclusa* Wlk., Wlk. Cat., 7 : 1737 ; Hampson, FBI, 1 : 453 (1892).
*N. W. Himalayas. [Poona; Java.]

242. *Euproctis albodentata* Moore, PZS, p. 401 (1879); Hampson, FBI, 1 : 481 (1892).
*N. W. Himalayas. [Burma.]

243. *Euproctis carvina* Moore, ANMH (4) 20 : 345; Hampson, FBI. 1 : 475 (1892).
*Kashmir. [Ceylon.]

244. *Euproctis icilia* Stoll., Cram. Pap. Exot., 5 : 158;Hampson, FBI, 1 : 479 (1892).
*N. W. Himalayas. [S. India; Ceylon.]

245. *Euproctis latifascia* Wlk., Wlk. Cat., 4 : 831; Hampson, FBI, 1 : 472 (1892).
*Kashmir; *Dharamsala. [Nepal; Manipur.]

246. *Euproctis lunata* Wlk., Wlk. Cat., 4 : 837; Hampson, FBI, 1 : 472 (1892).
*N. W. Himalayas. [Bengal.]

247. *Euproctis vitellina* Koll. Hungel's Kaschm., 4 : 471; Hampson, FBI, 1 : 476 (1892).
*N. W. Himalayas.

248. *Gazalina apsara* Moore, Lep. E. I. Co., p. 341; Hampson, FBI, 1 : 468 (1892).
*N. W. Himalayas. [Sikkim.]

249. *Gazalina chrysolopha* Koll, Hugel's Kaschm., 4 : 470; Hampson, FBI, 1 : 469 (1892).
*N. W. Himalayas. [Sikkim.]

250. *Himala argentea* Wlk., Wlk. Cat., 4 : 427; Hampson, FBI, 1 : 468 (1892).
*N. W. Himalayas. [Dehra Dun; Sikkim; Assam.]

251. *Lachana ladacensis* Moore, PZS, p. 398 (1888); Hampson, FBI, 1 : 435 (1892).
*Kashmir; *Ladak.

252. *Laelia exclamationis* Koll., Hugel's Kaschm., 4 : 469; Hampson, FBI, 1 : 442 (1892).
*N. W. Himalayas. [Sikkim.].

253. *Laelia heterogyna* Hampson, FBI, 1 : 443 (1892).
*Kashmir; *Drás.

254. *Laelia umbrina* Moore, PZS, p. 398 (1888); Hampson, FBI, 1 : 442 (1892).
*Kulu.

255. *Lymantiria concolor* Wlk., Wlk. Cat., 4:876; Hampson, FBI, 1: 462 (1892).
*N. W. Himalayas. [Sikkim; Sylhet; Nagas; Burma.]

256. *Lymantiria mathura* Moore, PZS, p. 805; Hampson, FBI, 1 : 464 (1892).
*N. W. Himalayas. [Sikkim.]

257. *Lymantiria obfuscata* Wlk., Wlk. Cat. 32 : 367; Hampson, FBI, 1 : 460 (1892).
*N. W. Himalayas.

258. *Varmina indica* Wlk., Wlk. Cat., 5 : 1039; Hampson, FBI, 1 : 435 (1892).
*N. W. Himalaysas.

Family CALLIDULIDAE

259. *Pterodecta anchora* Moore, Pagenst. Jb. Nassak. Ver., p. 238 pl. ii, fig. 24 (1887); Hampson, FBI, 1 : 325 (1892).
*Kulu. [Kulu to Bhutan.]

Family DREPANULIDAE

260. *Auzata semipavonaria* Wlk., Wlk. Cat., 26 : 1620; Hampson, FBI, 1 : 331 (1892).
*Kulu. [Simla; Sikkim.]

261. *Cilix glaucata* Scop., Ent. Carn., p. 221; Hampson, FBI, 1 : 347 (1892).
*Dalhousie. [Simla; N. America; Europe.]

262. *Deroca hyalina* Wlk., Wlk. Cat., 5 : 823; Hampson, FBI, 1 : 344 (1892).
*N. W. Himalayas. [Sikkim; Nagas; Manipur; E. Pegu.]

263. *Deroca inconclusa* Wlk., Wlk. Cat., 7 : 1727; Hampson, FBI, 1 : 344 (1892).
*N. W. Himalayas. [Japan; Nagas; Manipur.]

264. *Drepana hyalina* Moore, PZS, p. 401 (1888); Hampson, FBI, 1: 334 (1892).
*Kulu; *Dharamsala.

265. *Drepana innotata* Hampson, FBI, 1 : 335 (1892).
*Kulu.

266. *Oreta obtusa* Wlk., Wlk. Cat., 5 : 1167; Hampson, FBI, 1 : 349 (1892).
*Kashmir. [Sikkim; Sylhet.]

Family EPIPLEMIDAE

267. *Atossa neleinna* Moore, PZS, p. 577, pl. 67, fig. 7 (1874); Hampson, FBI, 3 : 136 (1895).
*N. W. Himalayas.

268. *Epiplema moza* Butl., ANMH, (5) : 402; Hampson, FBI, 3 : 126 (1895).
*Dalhousie. [Simla; Khasis; Japan.]

Family SPHINGIDAE

269. *Acosmeryx naga* Moore, Cat. Lep. E. I. Co., 1 : 271; Hampson, FBI, 1 : 83 (1892).
*N. W. Himalayas.

270. *Ambulyx exusta* Butl., D. Z. S., p. 252 (1875); Hampson, FBI, 1 : 80 (1892).
*N. W. Himalayas.

271. *Ambulyx rubiginosa* Moore, PSZ, p. 391 (1888); Hampson, FBI, 1 : 78 (1892).
N. W. Himalayas.

272. *Ambulyx substrigilis* Westw., Cab. Or. Ent., 61, pl. 30, fig. 2; Hampson, FBI, 1 : 77 (1892).
*N. W. Himalayas. [Sikkim; Assam; Silhet; Ceylon.]

273. *Ampelophaga rubiginosa* Bremer & Grey, Schmett. nordl. China, p. 11; Hampson, FBI, 1 : 83 (1892).
*N. W. Himalayas. [Amur; Sikkim; Nagas.]

274. *Chaerocampa mirabilis* Butl., PZS, 1875 : 248; Hampson, FBI, 1 : 93 (1892).
*N. W. Himalayas.

275. *Dilephila galii* Rolh., Natur., 7 : 107 (1775); Hampson, FBI, 1 : 98 (1892).
*Kashmir; [Europe; Gurias Valley.]

276. *Dilephila livornica* Esp. Schmett., 2 : 87, 196, pl. viii, fig. 4 ; Hampson, FBI, 1 : 97 (1892).
*N. W. Himalayas. [Europe, N. Africa; Aden; China.]

277. *Hemaris rubra* Hampson, FBI, 1 : 120 (1892).
*Kashmir. [Sind and Gurais Valley.]

278. *Hemaris saundersi* Wlk., Wlk. Cat., 8 : 83; Hampson, FBI, 1 : 119 (1892).
*N. W. Himalayas. [Punjab.]

279. *Leucophlebia emittens* Wlk., Wlk. Cat., 35 : 1858; Hampson, FBI, 1 : 75 (1892).
*N. W. Himalayas. [Sikkim; Bombay; C. India.]

280. *Polyptychus dentatus* Cram., Pap. Exot., 2 : 42; pl. 125 G; Hampson, FBI. 1 : 69 (1892).
*N. W. Himalayas. [Bombay; Bengal.]

281. *Polyptychus dyras* Wlk., Wlk. Cat., 8 : 250; Hampson, FBI, 1 : 69 (1892).
N. W. Himalayas. [Assam; Canara; Ceylon; Andamans.]

282. *Protoparca uniformis* Butl., PZS, p. 261 (1875); Hampson, FBI, 1 : 104 (1892).
*N. W. Himalayas.

283. *Pseudophinx grisea* Hampson, FBI, 8 : 104 (1892).
*Kulu.

Family GEOMETRIDAE

284. *Abraxas adustata* Schiff., Wien. Verz. p. 114; Hamson, FBI, 3 : 304 (1895).
*N. W. Himalayas. [Europe.]

285. *Abraxas fuscescens* Butl., PZS, p. 392, p. xxxv, fig. 10 (1886) ; Hampson, FBI, 3 : 303 (1895).
*Kulu. [Thurdiani, Punjab; Nilgiris.]

286. *Abraxas virginalis* Butl., PZS, p. 392, p. xxxv fig. 11 (1886); Hampson, FBI, 3 : 301 (1895).
*Kashmir; Murree. [Assam; Burma.]

287. *Acidalis holosericata* Dup., Lep. France, Suppl., 4: 109, pl. 59, fig. 7; Hampson, FBI, 3 : 440 (1895).
*N. W. Himalayas. [Europe; Sikkim.]

288. *Anaitis aequilineata* Wlk., Wlk. Cat., 26 : 1635; Hampson, FBI, 3 : 341 (1895).
*N. W. Himalayas.

289. *Anaitis fulgurata* Guen., Phal., 2 : 498; Hampson, FBI, 3 : 342 (1895).
N. W. Himalayas. [Sikkim.]

290. *Anaitis postochrea* Hampson, FBI, 3 : 343 (1895).
*Kulu.

291. *Anaitis pudicata* Guen., Phal., 2 : 497; Hampson, FBI, 3 : 341 (1895).
*N. W. Himalayas. [Afganistan; Sikkim.]

292. *Anonychia grisea* Butl., PZS., p. 172 (1883); Hampson, FBI, 3 : 178 (1895).
*N. W. Himalayas. [Sikkim; Khasis.]

293. *Anonychia lativitta* Moore, Lep. Atk., p. 279; Hampson, FBI, 3 : 179 (1895).
*N. W. Himalayas.

294. *Asthena plurilinearia* Moore, PZS., p. 645 (1867); Hampson, FBI, 3 : 417 (1895).
*N. W. Himalayas. [Sikkim; Khasis.]

295. *Bapta mytylata* Guen., Phal., 2 : 58; Hampson, FBI, 3 : 155 (1895).
*N. W. Himalayas. [Thundiani, Punjab; Sikkim; Khasis.]

296. *Bapta platyleucata* Wlk., Wlk. Cat., 35 : 1628; Hampson, FBI, 3 : 155 (1895).
*Gulmarg, Kashmir. [Sikkim; Khasis.]

297. *Biston congnataria*, Guen., Phal., 1 : 208; Hampson, FBI, 3 : 346 (1895).
*N. W. Himalayas. [N. America.]

298. *Biston regalis* Moore, Lep. Atk., p. 243; Hampson, FBI, 3 : 245 (1895).
*N. W. Himalayas. [Japan; Khasis.]

299. *Boarmia admissaria* Guen., Phal., 1 : 239 ; Hampson, FBI, 3 : 269 (1995).
*N. W. Himalayas. [Bhutan; Khasis.]

300. *Boarmia comparataria* Wlk., Wlk. Cat., 35 : 1582; Hampson, FBI, 3 : 263 (1895).
*N. W. Himalayas. [Sikkim; Travancore.]

301. *Boarmia crepuscularia* Hubn., Sammul. Eur. Schmett., Geom., fig. 158; Hampson, FBI, 3 : 260 (1895).
*N. W. Himalayas. [Sikkim; Khasis; Europe; Japan; China.]

302. *Boarmia qranitaria* Moore, Lep. Atk., p. 246; Hampson, FBI, 3 : 274 (1895).
*N. M. Himalayas. [Sikkim.]

303. *Boarmia nigridosaria* Guen., Phal., 1 : 232; Hampson, FBI, 3 : 267 (1895).
N. W. Himalayas. [Sikkim.]

304. *Boarmia ochrifasciata* Moore, Lep. Atk., p. 240; Hampson, FBI, 3 : 259 (1895).
*Dalhouse; *Dharamsala. [Sikkim; Khasis.]

305. *Boarmia pannosaria* Moore, PZS., p. 629 (1867); Hampson FBI, 3 : 281 (1895).
*Dalhousie. [Sikkim; Khasis.]

306. *Boarmia seripturaria* Wlk., Wlk. Cat., 35 : 1590; Hampson, FBI, 3 : 282 (1895).
*Kulu. [Sikkim; Bhutan; Khasis; Nagas.]

307. *Boarmia semiallea* Moore, Lep. Atk., p. 241; Hampson, FBI, 3 : 266 (1895).
*N. W. Himalayas. [Sikkim; Khasis.]

308. *Boarmia semiclarata* Wlk., Wlk. Cat., 24 : 1029; Hampson, FBI, 3 : 367 (1895).
N. W. Himalayas. [Sikkim; Khasis.]

309. *Boarmia subplagiata* Wlk., Wlk. Cat., 21 : 319; Hampson, FBI, 3 : 275 (1895).
*N. W. Himalayas. [Sikkim; Japan.]

310. *Boarmia trispinaria* Wlk., Wlk. Cat., 21 : 378; Hampson, FBI, 3 : 270 (1895).
*Kulu. [Sikkim; Khasis; Upper Burma; Margui.]

311. *Caberodes dentisignata* Moore, PZS, p. 636 (1867); Hamapson, FBI, 3 : 158 (1895).
*Dalhousie. [Sikkim.]

312. *Gataclysma conturbata* Wlk., Wlk., Cat. 26 : 1703; Hampson, FBI, 3 : 349 (1895).
N. W. Himalayas. [Khasis.]

313. *Cataclysma obliquilineata* Hampson, FBI, 3 : 349 (1895).
*Dalhousie.

314. *Cidaria aurigena* Butl., ANMH (5) 5 : 230; Hampson, FBI, 3 : 360 (1895).
*Dalhousie. [Sikkim, Khasis.]

315. *Cidaira curcumata* Moore, Lep. Atk., p. 278; Hampson, FBI, 3 : 365 (1895).
*Dalhousie. [Simla; Sikkim; Khasis.]

316. *Cidaria divergens* Butl., Ill. Het., 7 : 118, pl. 137, fig. 1 18; Hampson, FBI, 3 : 366 (1895).
*Dalhousie; *Dharamsala.

317. *Didaria melidiata* Feld., Reis. Nov., pl. 132, fig. 42; Hampson, FBI, 3 : 353 (1895).
*Dalhousie.

318. *Cidaria nugata* Feld., Reis. Nov., pl. 132, fig. 39; Hampson, FBI, 3 : 355 (1899).
*Kashmir.

319. *Cidaria porphyriata* Moore, Lep. Atk., p. 376; Hampson, FBI, 3 : 360 (1895).
N. W. Himalayas. [Sikkim.]

320. *Cidaria silaceata* Schiff., Wien. Verz., p. 113; Hampson, FBI, 3 : 357 (1895).
*N. W. Himalayas. [Sikkim; Japan, Europe, U. S. A.]

321. *Cidaria subangulata* Koll., Hugel's Kaschm., 4 : 490; Hampson, FBI, 3 : 356 (1895).
*N. W. Himalayas. [Afganistan.]

322. *Cidaria subrubescens* Warr., PZS, p. 329 (1888); Hampson, FBI, 3 : 356 (1895).
*N. W. Himalayas.

323. *Cidaria ramalaria* Feld., Reis. Nov., pl. 132, fig. 31; Hampson, FBI, 3 : 353 (1895).
*Kulu; *Dharamsala.

324. *Craspedia extimaria* Wlk., Wlk. Cat., 23 : 782; Hampson, FBI, 3 : 427 (1895).
N. W. Himalayas. [Sikkim; Sylhet; Nagas.]

325. *Craspedia pallida* Warr., PZS, p. 322 (1888); Hampson, FBI, 3 : 433 (1895).
*N. W. Himalayas.

326. *Crocallis lentiginosaria* Moore, PZS, p. 622 (1867) Hampson, FBI, 3 : 231 (1895).
*Kulu; *Dharamsala. [Sikkim.]

327. *Dalima patularia* Wlk., Wlk. Cat., 20 : 247; Hampson, FBI, 3 240 (1895).
*N. W. Himalayas. [Sikkim; Khasis.].

328. *Elphos pardicelata* Wlk., Wlk. Cat., 26 : 1544; Hampson, FBI, 3 : 250 (1895).
*N. W. Himalayas. [Sikkim ; Sylhet; Khasis.]

329. *Erythrolophus persimilis* Moore, Lep. Atk., p. 254; Hampson, FBI, 3 : 454 (1895).
*N. W. Himalayas.

330. *Euchloris detrecta* Wlk., Wlk. Cat., 22 : 521; Hampson, FBI, 3 : 498 (1895).
*Kulu. [Campbellpur; Murree; Simla; Nagas.]

331. *Euchloris radiata* Wlk., Wlk. Cat., 26 : 1567; Hampson, FBI, 3 : 498 (1895).
*Kulu; *Dharamsala.

332. *Eurymene reticulata* Warr., PZS., p. 408 (1893); Hampson, FBI, 3 : 178 (1895).
*Dalhousie. [Sikkim.]

333. *Eupithecia acutangula* Hampson, FBI, 3 : 400 (1895).
*Dalhousie.

334. *Garaeus argillaceus* Butl., Ill. Het., 7 : 100, pl. 135, fig. 15; Hampson, FBI, 3 : 235 (1895).
*Dalhousie; *Dharamsala. [Sikkim; Shillong.]

335. *Garaeus signatus* Butl., PZS., p. 392, pl. 35, fig. 9 (1886); Hampson, FBI, 3 : 235 (1895).
*Kulu; *Kashmir; *Murree; [Thundiani.]

336. *Eupithecia latimadia* Hampson, FBI, 3 : 400 (1895).
*Dalhousie.

337. *Geometra flavifrontaria* Guen., Guen. Phal., 1 : 346; Hampson, FBI, 3 : 496 (1895).
*N. W. Himalayas.

338. *Gnophus accipitrarius* Guen., Guen., Phal., 1 : 300; Hampson, FBI, 3 : 252 (1895).
*N. W. Himalayas, [Shillong, Assam; Sibsagar.]

339. *Gnophus muscosarius* Wlk., Wlk. Cat., 35 : 1596; Hampson, FBI, 3 : 251 (1895).
*N. W. Himalayas. [Sikkim.]

340. *Heterolocha falconaria* Wlk., Wlk. Cat., 35 : 1665; Hampson, FBI, 3 : 179 (1895).
*N. W. Himalayas. [Punjab; Sikkim.].

341. *Heterolocha phaenicoeniata* Holl., Hugel's Kaschm., 4 : 487; Hampson, FBI, 3 : 179 (1895).
*N. W. Himalayas.

342. *Hypochrosis pachiaria* Wlk., Wlk. Cat., 20 : 247; Hampson, FBI, 171 (1895).
*Kulu. [Sikkim; Khasis; Nilgiris.]

343. *Larentia affinis* Moore, Lep. Atk., p. 277; Hampson, FBI, 3 : 375 (1895).
*N. W. Himalayas. [Sikkim.]

344. *Larentia albigirata* Koll., Hugel's Kaschm., 4 : 489; Hampson, FBI, 3 : 367; (1895).
*N. W. Himalayas. [Japan.].

345. *Larentia dentifasciata* Hampson, FBI, 3 : 379 (1895).
*Dalhousie. *Murree.

346. *Larentia flavistrigata* Warr., PZS, (1888) p. 329; Hampson, FBI, 3 : 371 (1895).
*N. W. Himalayas.

347. *Larentia latifusata* Wlk., Wlk. Cat., 25 : 1298; Hampson, FBI, 3 : 370 (1895).
*Dalhousie. *Murree.

348. *Larentia minuta* Butl., Ill. Het., 7 : 117; pl. 137, fig. 15, 16; Hampson, FBI, 3 : 374 (1895).
*N. W. Himalayas. [Sikkim; Nagas.]

349. *Larentia schistacea* Moore, Lep. Atk., p. 273; Hampson, FBI, 3 : 376 (1895).
*Dalhousie. [Sikkim.].

350. *Larentia seriata* Moore, Lep. Atk., p. 278; Hampson, FBI, 3 : 373 (1895).
*N. W. Himalayas.

351. *Leptomiza calceria* Wlk., Wlk. Cat., 20 : 132; Hampson, FBI, 3 : 231 (1895).
*N. W. Himalayas. [Sikkim.].

352. *Loxaspilates obliquaria* Moore, P ZS., p. 649; Hampson, FBI, 3 : 181 (1895).
*N. W. Himalayas. [Afganistan; Sikkim.]

353. *Naxa testilis* Wlk., Wlk. Cat., 7 : 1743; Hampson, FBI, 3 : 324 (1895).
*N. W. Himalayas. [Amur; Sikkim; Bhutan; Assam; Nilgiris; Ceylon; Burma; Borneo].

354. *Peratophyga aerata* Moore, PZS, 1867 : 643; Hampson, FBI, 3 : 164 (1895).
*Kulu. [Japan; Simla; Khasis.]

355. *Phibalopteryx plurilineata* Moore, Lep. Atk., p. 273; Hampson, FBI, 3 : 346 (1895).
*N. W. Himalayas. [Khasis.]

356. *Photoscotosia amplicata* Wlk., Wlk. Cat., 25 : 1404; Hampson, FBI, 3 : 382, (1895).
*N. W. Himalayas. [China; Tibet; Sikkim.]

357. *Photoscotosia miniosata* Wlk., Wlk. Cat., 25 : 1354; Hampson, FBI, 3 : 380 (1895).
*N. W. Himalayas. [Sylhet.].

358. *Psyra cuneata* Wlk., Wlk. Cat., 21 : 438; Hampson, FBI, 3 : 223 (1895).
*N. W. Himalayas. Japan; Sikkim; Khasis.

359. *Psyra spureataria* Wlk., Wlk. Cat., 26 : 1498; Hampson, FBI, 3 : 221 (1895).
*N. W. Himalayas. [Sikkim; Khasis.]

360. *Rhodostrophia cinerascens* Moore, Lep. Atk., 264; Hampson, FBI, 3 : 458 (1895).
*Kashmir. [Afganistan.]

361. *Rhodostrophia hebricolens* Butl., PZS., p. 173 (1883); Hampson, FBI, 3 : 457 (1895).
*N. W. Himalayas.

362. *Rumia crataegata* Linn., Faun. Suec., 336; Hampson, FBI, 3 : 183 (1895).
N. W. Himalayas.

363. *Rumia irrorata* Hampson, FBI, 3 : 184 (1895).
*Dalhousie.

364. *Scotosia dubiosata* Wlk., Wlk. Cat., 25 : 1352; Hampson, FBI, 3 : 344 (1895).
*N. W. Himalayas. [Sikkim; Nilgiris; Afganistan.]

365. *Stamnodes pamphilata* Feld., Reis. Nov., pl. 132, fig. 34; Hampson, FBI, 3 : 423 (1895).
*Kulu; *Dharamsala. [Thundiani.]

366. *Stenorumia ablunata* Guen., Guen. Phal., 1 : 110; Hampson, FBI, 3 : 183 (1895).
*N. W. Himalayas.

367. *Stenorumia duplicilinea* Hampson, FBI, 3 : 183 (1895).
*Dalhousie.

368. *Tanaorrhinus vittatus* Moore, PZS., p. 636 (1867); Hampson, FBI, 3 : 494 (1895).
*N. W. Himalayas. [Japan; Sikkim; Khasis.]

369. *Trichopterigia rufinotata* Butl., Ill. Het., 7 : 116, pl. 137; Hampson, FBI, 3 : 404 (1895).
*Kulu.

370. *Urapteryx ebuleata* Guen., Guen. Phal., 1 : 32; Hampson, FBI, 3 : 145 (1895).
*N. W. Himalayas. [Sikkim; Khasis; Shillong.]

371. *Urapteryx excellens* Butl., Ill. Het. 7 : 99, pl. 135, fig. 13 ; Hampson, FBI, 3 : 147, (1895).
*Kashmir.

372. *Venusia dharmsalae* Butl., PZS., p. 169 (1883) ; Hampson, FBI, 3 : 417 (1895).
*Kulu; *Dharamsala.

373. *Xandrames latiferaria* Wlk., Wlk. Cat., 21 : 445; Hampson, FBI, 3 : 250 (1895).
*N. W. Himalayas. [Khasis; Sikkim; Japan; China.]

Family CYMATOPHORIDAE

374. *Thyatira batis* Linn., Syst. Nat., 1 : 836; Hampson, FBI, 1 : 180 (1892).
N. W. Himalayas. [Sikkim; Java.]

Family LASIOCAMPIDAE

375. *Arguda albigutta* Wlk., Wlk. Cat., 6 : 1419; Hampson, FBI, 1 : 414 (1892).
*N. W. Himalayas. [Australia; Tasmania.]

376. *Odonestis laeta* Wlk., Wlk. Cat., 6 : 1416; Hampson, FBI, 1 : 426 (1892).
*N. W. Himalayas. [Sikkim; Sylhet; Burma; Sumatra.]

377. *Odonestis pyriformis* Moore, PZS, p. 408 (1879), pl. 34, fig. 7; Hampson, FBI, 1 : 427 (1892).
*N. W. Himalayas. [Sikkim.]

378. *Taragama dorsalis* Wlk. Wlk. Cat., 35 : 1947; Hampson, FBI, 1 : 405 (1892).
*N. W. Himalayas. [Calcutta; S. India; Ceylon; Philippines.]

Family BOMBYCIDAE

379. *Ocinara signifera* Walk., J. Linn. Soc., 6 : 130 (1892); Hampson, FBI, 1 : 34 (1892).
*N. W. Himalayas. [Sikkim;Khasi Hills; Nilgiris; Andaman; Sumatra; Borneo.]

Family SATURNIIDAE

380. *Saturnia huttoni* Moore, Trans. ent. Soc., (3) 1 : 321; Hampson, FBI, 1 : 24 (1892).
*N. W. Himalayas.

381. *Saturnia lindia* Moore, Trans. ent. Soc. (3) 2 : 428, pl. xxii, fig. 3; Hampson, FBI, 1 : 23 (1892).
*Kulu.

382. *Saturnia simla* Westw., Cab. Or Ent., p. 41, pl. xx fig. 1; Hampson, FBI, 1 : 23 (1892).
*N. W. Himalayas.

383. *Saturnia stoliczkana* Feld., Reis. Nov., pl. 37, fig. 3; Hampson, FBI, 1 : 24 (1892).
*N. W. Himalayas. *Ladak; *Yarkand.

Family EUPTEROTIDAE

384. *Apona cashmirensis* Koll., Hugel's Kaschm., 4: 472, pl. xxi, fig. 4; Hampson, FBI, 1 : 52 (1892).
*N. W. Himalayas. [Sikkim.]

385. *Ganisa postica* Wlk., Wlk. Cat., 5 : 1190; Hampson, FBI, 1 : 49 (1892).
*Kulu; *Kangra; [Sikkim; Sylhet; Nagas; Ceylon.]

386. *Sangatissa subeurivifera* Wlk., Wlk. Cat., 32 : 375; Hampson, FBI, 1 : 63 (1892).
*N. W. Himalayas. [S. India; Ceylon; Yunnan.]

Family LIMACODIDAE

387. *Altha rivea* Wlk., J. Linn. Soc., 6 : 173; Hampson, FBI, 1 : 397 (1892).
*Kulu. [Simla; Sikkim; Sibsagar; Ranchi; S. India; Ceylon.]

388. *Contheula melanosticta* Hampson, FBI, 1 : 385 (1892).
*N. W. Himalayas. *Mandi. [Jubbalpore.]

389. *Miresa inornata* Wlk., Wlk. Cat., 5 : 1125; Hampson, FBI : 1.
*N. W. Himalayas. [Japan; China.]

390. *Thosea cana* Wlk., Wlk. Cat., 32 : 484; Hampson, FBI, 1 : 378 (1892).
*Kulu. [Sikkim; Poona; Nilgiris; Ceylon.]

Family SYNTOMIDAE

391. *Callitomis leucosoma* Butl., J. Linn. Soc. Zool., 7 : 351; Hampson, FBI, 1 : 225 (1892).
*Kashmir.

392. *Callitomis syntomoides* Butl., J. Linn. Soc. Zool., 1 2 : 351; Hampson, FBI, 1 : 224 (1892).
*Kashmir; [Sind Valley; Simla.]

393. *Naelia punctata* Fabr., Sp. Ins., 2 : 207; Hampson, FBI, 1 : 226 (1892).
*Kashmir. [Europe.]

394. *Syntomis bicincta* Koll., Hugel's Kashm., 4 : 460, pl. xix, fig. 8; Hampson, FBI, 1 : 213 (1892).
*Kulu; *Kangra. [Sikkim; Khasi Hills.]

395. *Syntomis confinis* Wlk., Wlk. Cat., 1 : 149; Hampson, FBI, 1 : 223 (1892).
*Kulu. [Almora.]

396. *Syntomis georgina* Butl., J. Linn. Soc. Zool., 12 : 346; Hampson, FBI, 1 : 213 (1892).
*N. W. Himalayas.

Family SESUDAE

397. *Melittia kulvana* Moore, PZS., p. 392 (1888); Hampson, FBI, 1 : 204 (1892).
*Kulu.

398. *Sesia xanthosticta* Hampson, FBI, 1 : 197 (1892); .
*Kashmir.

399. *Sphecodoptera flavicollis* Hampson, FBI, 1 : 190 (1892).
*Kashmir : Skardo.

Family PAPILIONIDAE

400. *Chilasa agestor* govindra (Moore), in Lang & Moore, Ent. Month, Mag. 1 : 101; Talbot, FBI, 1 : 108 (1939).
*Kashmir. [Kashmir to Kumaon.]

401. *Chilasa agestor chiraghashahi* (Bang-Hass), Ent. Z., 46 : 261; Talbot, FBI. 1 : 108 (1939).
*Western Kashmir. *Punch State; Jhelum River.

402. *Graphium cloanthus cloanthus* (Westwood), Arc. Ent., 1 : 42, pl. ii, fig. (1841) (Papilio).
Talbot, FBI, 1 : 218 (1939).
*Kashmir. [Kashmir to Burma.]

403. *Graphium eurous cashmirinsis* (Rothschild), Nouv. Zool., 2 : 407-8 (1895) (Papilio); Talbot, FBI, 1 : 204 (1939).
*Kashmir. [Kashmir to Kumaon.]

404. *Graphium sarpedon sarpedon* (Linn.), Syst. Nat., p. 461 (1758) ; Talbot, FBI, 1 : 220 (1939).
*Kashmir. [Kashmir to Burma.]

405. *Papilio polyctor* Boisduval, Spec. Guen. Lep., 1 : 205 (1836); Bingham, FBI, 2 : 82 (1907).
*Kashmir. [Kashmir to Kumaon. Nepal.]

406. *Papilio cloanthus* Westwood, Araena Ent., 1 : 42, pl. ii, fig. 2, (1841); Bingham, FBI, 2 : 111 (1907).
*Kashmir. [Kashmir to Sikkim; Bhutan; Assam; Burma.]

407. *Papilio protenor protenor* Cramer, Pap. Exot., 1 : 77 (1775); Talbot, FBI, 1 : 141 (1939).
*Kashmir. [Kashmir to Kumaon.]

408. *Papilio areturus arius* (Rothshild), Nov. Zool., 15; 174 (1908) ; Talbot, FBI, 1 : 152 (1939).
*Kashmir. [Kashmir to Kumaon.]

409. *Papilio demoleus* Linn., Syst. Nat., 10 : 464 (1758); Bingham, FBI, 2 : 39 (1907).
*Kashmir. [Kashmir to Ceylon; Assam to Burma.]

410. *Papilio govindra* Moore, Ent. Month. Mag., 1864-64; 101; Bingham, FBI, 2 : 71 (1907).
*Kashmir. [Kashmir to Kumaon.]

411. *Papilio machaon asiatica* (Menetries), Eumn. Crop. Anim. Mus., 1 : 70 (1855); Talbot, FBI, 1 : 194 (1939).
*Kashmir. [North of Indus, Chitral, Kashmir to Tibet.]

412. *Papilio machaon ladakensis* (Moore), J. As. Soc. Bengal, 53 : 46 (1884); Tablot, FBI, 1 : 196 (1939).
*Ladak.

413. *Papilio philoxwnus* Gray, Zool. Misc., (1831) : 32; Bingham, FBI, 2 : 31 (1907).
*Kashmir. [Kashmir to Sikkim; Bhutan; Assam; Upper Burma; Tenasserim.]

414. *Papilio ravana* Moore, Cat. Lep. Mus. E. I. Co., 1 : 96 (1857); Bingham, FBI, 2 : 33 (1907).
*Kashmir to *Kulu.

415. *Parnassius accopun djabensis* Bang-Hass, Horae Macrolep., 1: 23, t. iv figs. 3, 4 (1927); Tabolt, FBI, 1 : 296 (1939).
*E. Spiti. [Tum-Tum-Thang Mts.]

416. *Parnassius acco* (Gray), in Talbot, FBI, 1 : 294 (1939).
*Ladak. [Ladak to Nepal and Sikkim.]

417. *Parnassius acco lagalangi* Bang-Hass, Horae Macrolep., 1 : 23 (1927); Tablot, FBI, 1 : 295 (1939).
*S. Ladak. [Tagalang-La.]

418. *Parnassius aetius* (Evers.) in Talbot, FBI, 1 : 262 (1939).
*Kashmir.

419. *Parnassius charltonius bryki* Haude, Soc. Ent., 27 : 75 (1912); Talbot, FBI, 1 : 299 (1939).
*Spiti. [Nilang Pass; Tauling Pass to Shipki Pass; Tum-Tum-Tang. Mts.]

420. *Parnassius charltonius charltonius* Gray, Cat. Lep. Brit. Mus. p. 77, pl. xii, fig. 7 (1852); Talbot, FBI, 8 : 298 (1939).
*Ladak. [Ladak to Kumaon.]

421. *Parnassius charltonius deckerti* Varity, Rhop. Palaear., p. 85 (1907-11); Talbot, FBI, 1 : 299 (1939).
*Kashmir.

422. *Parnassius hardwickei* Gray, Zool. Misc., 1 : 32 (1832); Bingham, FBI, 2 : 121 (1907).
*Kashmir to *Kulu. [Nepal; Sikkim.]

423. *Parnassius deplphius* Eversmann, Bull. Mosc., p. 541, pl. 7, fig. 1 (1843); Talbot, FBI, 1 : 278 (1939).
*Ladak; N. W. Himalayas to Karakorum; *Rupshu.

424. *Parnassius delphius cardinalina* Avinoff., Trans. ent. Soc. Lond., 355 (1916); Talbot, FBI, 1 : 282 (1939).
*Kashmir. [Burzil Pass.]

425. *Parnassius delphius ladakensis* Avinoff., Trans. ent. Soc. Lond., 354 (1916).
*Ladak. [Shera-la.]

426. *Parnassius delphius mamaierei* Bang-Hass., DEZ, 29 : 98 (1915); Talbot, FBI, 1 : 283 (1939).
*S. & W. Ladak.

427. *Parnassius delphius rupshuana* Avinoff., Trans. ent. Soc. Lond., 354 (1916); Talbot, FBI, 1 : 284 (1939).
*S. & W. Ladak; *Rupshu.

428. *Parnassius epaphus hillensis* Bang-Hass, DEZ, 29 : 175 (1915); Talbot, FBI, 1 : 267 (1939).
*The Spiti distt. of Bashahr.

429. *Parnassius epqphus hinducucica* Bang-Hass., Ent. Zeit., 48 : 7 (1934); Talbot, FBI, 1 : 267 (1939).
*N. Kashmir. [Chitral; Hindukush; Karambear Pass.]

430. *Parnassius jacquemontii jacquemontii* (Boisduval), Spec. Gen. Lep., 1 : 400; Talbot, FBI, 1 : 265 (1939).
*Kashmir. [Kashmir to Kumaon.]

431. *Parnassius stoliczkanus* Felder, in Talbot, FBI, 1 : 272 (1939).
*Kashmir; *Ladak; *Kulu; N. Kashmir to Ladak. [Kumaon.]

432. *Parnassius stoliczkanus atkinsoni* Moore, in Talbot, FBI, 1 : 274, (1939).
*Kashmir; *Pir Panjal. E. Gilgit; Haramosh Mt.

433. *Parnassius stoliczkanus nicevillei* Avinoff. Trans. ent. Soc., p. 355 (1916); Talbot, FBI, 1 : 273 (1939).
*Kashmir. [Burzil Pass.]

434. *Parnassius stolickanus spitiensis* Bang-Hass, Horae Macrolep., p. 33, (1927); Talbot, FBI, 1 : 276 (1939).
*Spiti. [Tum Tum Thang Mts.]

435. *Parnassius stoliczkanus stoliczkanus* Felder, Reis. Novara, p. 138 (1865); Talbot, FBI, 1 : 275 (1939).
*Ladak to Kulu.

436. *Parnassius stoliczkanus zogilaica* Tytler, JENHS, 31 : 251 (1926); Talbot FBI, 1 : 274 (1939).
*N. Kashmir; *Zogila Pass.

437. *Parnassius simo saserensis* Bang-Hass, Ent. Zeit., 51 : 342 (1937). Talbot FBI, 1 : 291 (1939).
*N. Kashmir; *Saser Pass.

438. *Parnassius simo simoides* (Bang-Hass), in Tablot, FBI, 1 : 292 (1939).
*Ladak; *Zanskar; *S. W. Leh.

439. *Parnassius simo simonides* Austant, Ent. Zeit., 5 : 360, fig. 4; Talbot, FBI, 1 : 291 (1939).
*N. Ladak.

440. *Parnassius simo zarraensis* Bang-Hass, Ent. Zeit., 48 : 152 (1934); Talbot, FBI, 1 : 291 (1939).
*S. E. Kashmir; Tagalang La Pass; *Zarra.

441. *Polydorus dasarada ravana* (Moore), Cat. Lep. Mus. E. I. C., 1 : 96 (Papilio); Talbot, FBI, 1 : 99 (1939).
*Kashmir. [Kashmir to Kumaon.]

Family PIERIDAE

442. *Anaphaeis mesentissa* (Crammer), Pap. Exot., 3 : 270, (1782); (Papilio); Bingham, FBI, 2 : 155 (1907).
*Kashmir. [Kashmir to Sikkim; Nilgiris.]

443. *Aporia leucodica balucha* Marshall, PZS, (1882) : 760; Talbot, FBI, 1 : 312 (1939).
*Ladak. [Baluchistan to Chitral & Ladak.]

444. *Aporia leucodica soracta* Moore, Cat. Lep. Mus. E. I. C., 1 : 83 (1882), pl. ii, fig. 5; Talbot, FBI, 1 : 313 (1939).
*Kashmir. [Kashmir to U. P., Mussoorie.]

445. *Aporia agathon phyryxe* (Boisduval), Spec. Gen. Lep., 1 : 446 (1836) (Pieris); Talbot, FBI, 1 : 317 (1939).
*Kashmir. [Kashmir to Garhwal.]

446. *Aporia nabellica nabellica* (Boisduval) Spec. Gen., Lep., 1 : 509 (1836) (Pieris); Talbot, FBI, 1 : 315 (1939).
*Kashmir. [Kashmir to Kumaon.]

447. *Baltia shawi* (Bates), Talbot, FBI, 1 : 308 (1939)
*Ladak. [Chitral to Ladak.]

448. *Baltia butleri butleri* (Moore), PZS, (1882) : 256; Talbot, FBI, 1 : 309 (1939).
*Ladak. [Ladak to Kumaon.]

449. *Colias cocaudica* Erschoff., in Talbot, FBI, 1 : 546 (1939).
*Ladak. [Turkestan to W. China; Hindu Kush, Tibet.]

450. *Coliascocandica thrasibulus* Frush, in Talbot, FBI, 8 : 547 (1939).
*Ladak. [Chonging Valley; Kardong Pass.]

451. *Colias eogene eogene* Felder, Reise Novara, 2 : 196 (1865); Talbot, FBI, 1: 555 (1939).
*Ladak. [E. Karakorum to Kumaon.]

452. *Colotis etrida* (Boisduval), Sp. Gen. Lep. 1 : 576 (1836) (Anthocharis); Bingham, FBI, 2 : 270 (1907).
*Kashmir.

453. *Colias eogene francesea* Watkins, ANMH, (9) 20 : 99 (1927). Talbot, FBI, 1 : 557 (1939).
*Kashmir. [Baltistan.]

454. *Colias ladakensis* Felder, Reis. Nov., 2 : 197 (1856); Talbot, FBI, 1 : 548 (1939).
*Kashmir. [Kashmir to Kumaon.]

455. *Colias nastes* Elves, JBNHS, 11 : 466 (1898); Bingham, FBI, 2 : 238 (1907).
*Ladak. [Chorging valley; Kardong Pass.]

456. *Colias stoliczkana* Moore, in Talbot, FBI, 1 : 558 (1939).
*Kashmir, Ladak. [Sikkim; Turkestan.]

457. *Colias stoliczkana stoliczkana* Moore, ANMH, (4) 20 : 229 (1878); Talbot, FBI, 1 : 559 (1939).
*Kashmir; *Ladak.

458. *Delias belladonna horsfieldi* (Grap), Zool. Misc., 1 : 32 (1831) (Pieris); Talbot, FBI, 1 : 340 (1939).
*Kulu. [Kulu to Kumaon. Nepal to Sikkim.]

459. *Gonepteryx mahagurn mahagurn* (Gistel) in Talbot, FBI, 1 : 510 (1939).
*Kashmir. [Kashmir to Kumaon. Murree, Mussoorie; Nainital.]

460. *Pieris canidia* Sparrman, Ameon. Acad., 7 : 1768, p. 504; Bingham, FBI 2 : 172 (1907).
*Kashmir. [Kashmir to Sikkim; Bhutan, S. India, Assam, S. India, Upper Burma.]

461. *Pieris daplidice* (Linn), Syst. Nat., 10 : 468 (1758) (Papillio) Bingham, FBI, 2 : 175 (1907).
*Ladak, Kashmir. [Chitral; Baluchistan.]

462. *Pieris desta* (de Niceville), J. As. Soc. Bengal, 52 : 32 (1883); Talbot, FBI, 1 : 424 (1939).
*Kashmir to Ladak. [Pamirs.]

463. *Pieris krueperi devta* (de Niceville), J. As. Soc. Bengal, 52 : 82 (1883); Talbot, FBI, 1 : 418 (1939).
*Ladak, Kashmir. [Baluchistan to Kashmir.]

464. *Pieris rapae iranica* Le Cerf., ANMH Paris, 2 : 25 (1913); Talbot, FBI, 1: 428 (1939).
*Kashmir, Ladak. [Mesopotamia, N. Persia, Baluchistan, Chitral.]

465. *Pontia chloridice alpina* (Verity), in Talbot, FBI, 8 : 433, (1939).
*Ladak. [Baluchistan to Chitral and Ladak.]

Family NYMPHALIDAE

466. *Apatura ambica* Kollar, Hugel's Kaschmir, 4 : 431 (1844) Bingham, FBI, 1 : 230 (1905).
*Kashmir. [Kashmir to Sikkim; Assam; Burma; Siam.]

467. *Argynnis agldia* race *vitatha* Moore, PZS., p. 568 (1874); Bingham, FBI, 1 : 431 (1905).
*N. Kashmir. *Gurais; *Skero-la, [Chitral.]

468. *Arghnnis hegemone* Staud., Hor. Soc. Ent. Ross., 16 : 407; Bingham, FBI, 1 : 449 (1905).
*Ladak. [Hunza Valley. Chitral.]

469. *Argynnis childreni* Race *sakontala* Koll., Hugel's Kaschmir, 4 : 439 (1844); Bingham, FBI, 1 : 435 (1905).
*Kashmir. [Kashmir to Kumaon.]

470. *Argynnis jerodoni* Lang, Ent. month, Mag., 4 : 34 (1868); Bingham, FBI, 1 : 446 (1905).
*Kashmir.

471. *Argynnis kamala* Moore, Cat. Lep. Mus., E. I. C., 1 : 156 (1857); Bingham, FBI, 1 : 433 (1905).
*Kashmir. [Kashmir to Kumaon.]

472. *Arghnnis pales* race *generator*, Staud., Statt. ent. Zeit. p. 235 (1886); Bingham, FBI, 1 : 447 (1905).
*Kashmir, *Kulu. [Chumlei Valley; Sikkim.]

473. *Athyma asura* Moore, Cat. Lep. Mus. E. I. C., 1 : 171 (1857) pl. 51a, fig. 1 ; Bingham, FBI, 1 : 317 (1905).
*Kulu. [Simla to Mussoorie; Assam; Arrakan; Tenasserim]

474. *Aulocera brahminus* (Blanchard) Jacquem. Voy. Dan. l'Inde, Ins., 4: 22, pl. 2, fig. 4 (1884) (Satyrus); Bingham, FBI, 1 : 126 (1905).
N. W. Himalayas; *Kulu; *Kashmir. [Sikkim; Sylhet.]

475. *Aulocera padma* (Koll.), Hugel's Kaschm., 4 : 445, pl. 15, fig. 1, 2 (1844) (Satyrus); Bingham, FBI, 1 : 124 (1905).
*Kulu. [Kulu to Sikkim.]

476. *Aulocera saraswati* (Koll.), Hugel's Kaschm., 4 : 445, pl. 14, fig. 3, 4 (1944) (Satyrus); Bingham, FBI, 1 : 128 (1905).
*Kashmir. [Kashmir to Nepal.]

477. *Aulocera swaha* Koll., Hugel's Kaschmir., 4 : 444, pl. 14, fig. 1, 2 (1844) (Satyrus); Bingham, FBI, 1 : 126 (1905).
*Kashmir. [Kashmir to Kumaon.]

478. *Calingab udha* Moore, Cat. Lep. Mus., E. I. C., 1 : 163 (1857); Bingham, FBI, 1 : 466 (1905).
*Dalhousie; *Kulu.

479. *Danais aglea* race *melanoides* Cramer, Pap. exot., 4 : 377 (1781) (Papilio); Bingham, FBI, 1 : 18 (1905).
*Kashmir. [Kashmir to Nepal; Sylhet; Assam; Cachar; Shittagong; Arrakan; Burma; Tenasserim.]

480. *Danas tytia* Gray, Lep. Ins. Nepal, p. 2 (1833-46), fig. 2; Bingham, FBI, 1 : 13 (1905).
*Kashmir. [The Himalayas, Assam to Burma; Tenasserim; Malaya Pennin.]

481. *Dichorragia nesimachus* Boisduval, Croch. Cuv. Reg. Anim. Ins. 2 : 139 (1836); Bingham, FBI, 1 : 248 (1905).
*Kulu. [Kulu to Sikkim; Assam; Burma; Tenasserim.]

482. *Erebia annada* Moore, Cat. Lep. Mus., E. I. C., 1 : 226 (1857); Bingham, FBI, 1 : 150 (1905).
*Kashmir; [Kashmir to Bhutan.]

483. *Erebia daksha* Moore, PZS, p. 266, pl. 43, fig. 1 (1874) (Callerebia); Bingham, FBI, 1 : 152 (1905).
*Kashmir.

484. *Erebia hyagriva* Moore, Cat. Lep. Mus., E. I. C., 1 : 236 (1857) (Ypthima); Bingham FBI, 1 : 150 (1905).
*Kashmir to *Kulu.

485. *Erebia kalinda* Moore, PZS, 1865, p. 501, pl. 30, fig. 5; Bingham, FBI, 1 : 149 (1905).
*Kulu *Pangi [Kumaon; Kalwas.] .

486. *Erebia mani* Niceville, JASB, p. 247 (1880); Bingham, FBI, 1 : 148 (1905).
*Kashmir; *Ladak.

487. *Erebia scanda* Koll., Hugel's Kaschm., 4 : 452, pl. 17, fig. 3, 4 (1844); FBI, 1 : 151 (1905).
*Kashmir; [Kashmir to Kumaon.]

488. *Eulepis athamas* Drury, Ill. Exot. Ent., 1 : 5, pl. 2, fig. 4 (1770) (Papilio); Bingham, FBI, 1 : 220 (1905).
*Kashmir. [Kashmir to Sikkim; Central India; Eastern Ghats; Ceylon; Assam; Cachar; Burma; Tenasserim.]

489. *Eulepis dolon* Westw., Cab., Or. Ent., p. 55 (1848) (Charaxes); Bingham, FBI, 1 : 226 (1905).
*Kulu. [Kulu to Sikkim; Bhutan; Assam; Cachar; Burma; Tenasserim.]

490. *Kallima inachus* (Boisduval). in Bingham, FBI, 1 : 395 (1905).
*Kashmir. [Kashmir to Sikkim; Orissa; Eastern Ghats Pachmarhi; Assam; Burma, Tenasserim.]

491. *Karanasa huebneri* Felder, Novara Reise, Lep. Rhop., p. 494, pl. 69, fig. 8, 9 (1867); Bingham, FBI, 1 : 124 (1905).
*Ladak, *Kashmir; N. W. Himalayas.

492. *Karnasa pimpla* Felder, Novara Reise, lep. Rhop., p. 494 pl. 67, fig. 10, 11 (1867) (Satyrus); Bingham, FBI, 1 : 124 (1905).
N. W. Himalayas; *Ladak. [Baluchistan.]

493. *Lethe nicetas* Hewitson, Exot. Butt., 3 : 78 (1863) (Debis).
Bingham, FBI, 1 : 86 (1905).
*Kulu. [Kulu to Sikkim.]

494. *Lethe jalaurida* Niceville, JASB, p. 245 (1880) (Lophoessa) Bingham, FBI, 1 : 98 (1905).
*Kulu. [Kulu to Sikkim; W. China.]

495. *Lethe vaiva rata* Doherty, JASB, p. 115 (1886); Bingham, 1 : 85 (1905).
*Kulu. N. W. Himalayas. [Kulu to Mussoorie.].

496. *Lethe verma* (Koll.), Hugel's Kaschm., 4 : 447 (1844) (Satyrus) Bingham, FBI, 1 : 84 (1905).
*Kashmir. [Kashmir to Sikkim; Assam; Burma; Tenasserim.]

497. *Lethe yama* Moore, Cat. Lep. Mus. E. I. C., 1 : 221 (1857) (Zophoessa); Bingham, FBI, 1 : 103 (1905).
*Kulu. [Mussoorie; Bhutan; Assam; Khasi Hills; Burma].

498. *Libythea myrrha* Godark., Encycl. Meth., 9 : 171 (1819); Bingham, FBI, 1 : 475 (1905).
*Kulu. [Kulu to Sikkim; Bombay; S. India; Ceylon; Assam; Burma.]

499. *Liminitis ligyes* Hewirson, Trans. ent. Soc., (3) 2 : 246 (1864) ; Bingham, FBI, 1 : 298 (1905).
N. W. Himalayas. *Kashmir. [Chitral.]

500. *Liminitisotrivena* Moore, Ent. month. Mag., (1864) : 133; Bingham, FBI, 1 : 297 (1905).
N. W. Himalayas; *Kashmir to *Kulu.

501. *Maniola pulchella* race *pulchra* Felder, Novera Reise, Lep. hop., p. 481 (1867); Bingham, FBI, 1 : 121 (1905).
*Kashmir; *Ladak; *Dalhousie. [Chitral. Ganges Valley.]

502. *Maniola cheena* (Moore), PZS, p. 501, p. 30, fig. 6 (1865) (Epinephele); Bingham, FBI, 1 : 120 (1905).
*N. W. Himalayas. *Kashmir.

503. *Maniola coenonympha* Felder, Novara Reise, Lep. Rhop., p. 492 (1867) (Epinephele); Bingham, FBI, 1 : 122, (1905).
*Ladak; *Kashmir.

504. *Maniola devendra* Moore, PZS., p. 502 (1865) (Epinephele) Bingham, FBI, 1 : 119 (1905).
N. W. Himalayas, *Spiti; *Ladak.

505. *Melanitis bela* Moore, Cat. Lep. Mus. E. I. C., 1 : 223 (1857); Bingham, FBI, 1 : 159 (1905).
*Kashmir. [Kashmir to Sikkim; Assam; Naga; Khasi Hills; Burma; Tenasserim.]

506. *Melitaea sindura* race *balbita* (Moore), in Bingham, FBI, 1 : 451 (1905).
*Kashmir.

507. *Mycalesis malsara* race *lepcha* Moore, Cat. Lep. E. I. C., 1 : 231 (1857); Bingham, FBI, 1 : 64 (1905).
*Kulu. *Kangra. [The Himalayas; Mussoorie.]

508. *Mycalesis mineus* (Linn.), Syst. Nat., 1 : 768 (1767) (Papilio); Bingham, FBI, 1 : 58 (1905).

509. *Mycalesis sanatana* Moore, Cat. Lep., Mus., E. I. C., 1 : 231 (1857); Bingham, FBI, 1 : 55 (1905).
*Kulu. [Kulu to Sikkim; Khasi Hills; Burma, Tenasserim.]

510. *Neptis ananta* Moore, Cat., Lep. Mus. E. I. C. 1 : 166 (1857); Bingham, FBI, 8 : 340 (1905).
*Dalhousie; *Chamba. [Simla to Sikkim; Assam; Upper Burma.]

511. *Neptis mahendra* Moore, PZS., p. 560 (1872); Bingham, FBI, 329 (1905).
*Kashmir. [Busahir to Kumaon.]

512. *Neptis narayana* Moore, PZS, p. 6, (1858); Bingham, FBI, 1 : 334 (1905).
*Kulu. [Kulu to Kumaon.]

513. *Neptis sankara* Koll., Hugel's Kaschm., 4 : 428 (1844); Bingham, FBI, 1 : 322 (1905).
*Kashmir. [Kashmir to Kumaon. Nepal].

514. *Nytha baldiva* (Moore), PZS, p. 499 (1865) (Lasiommata); Bingham, FBI, 1 : 114 (1905).
*Ladak. [Hunza; Chitral.]

515. *Nytha staudura* (Marshall), JASB, p. 38 (1882) (Hipparchia) Bingham, FBI, 1 : 116 (1905).
*Northern Kashmir.

516. *Parage cashmirensis* Moore, PZS, p. 265 (1874); Bingham, FBI, 1 : 112 (1905).
*Kashmir.

517. *Pseudergolis wedah* Koll., Hugel's Kaschm. Bingham, FBI, 1 : 464 (1905).
*Kashmir. [Kashmir to Sikkim; Assam; Burma; Tenasserim.]

518. *Satyrus maeerula* Felder, Novara Reise, Lep. Rhop., p. 496 (1867) (Lasiommata); Bingham, FBI, 1 : 118 (1905).
*Kashmir; *Dalhousie; *Pangi; *Gonas Pass; N. W. Himalayas.

519. *Satyrus menava* (Moore), PZS., p. 499 (1865) (Lasiomanta); Bingham, FBI, 1 : 111 (1905).
*N. W. Himalayas; *Kashmir. [Chitral.]

520. *Sephisa dichoroa* (Koll.), Hugel's Kaschm., 4 : 429 (1844) (Lemenitis); Bingham, FBI, 8 : 245 (1905).
*Kashmir. [Kashmir to Kumaon.]

521. *Stibochiana nicea* (Gray), Lep., Ins. Nepal, p. 13 (1833-46) (Adolias); Bingham, FBI, 1 : 250 (1905).
*Kulu. [Kulu to Sikkim; Assam; Burma; Tenasserim.]

522. *Symbrenthia brabira* Moore, PZS, (1872); 558; Bingham, FBI, 1 : 378 (1905).
*Kashmir. [Kashmir to Sikkim. Nepal.]

523. *Vanessa c-album* (Linn.), Syst. Nat. 10: 477 (1758) (Papilio) Bingham, FBI, 1 : 372 (1905).
*Kashmir. [Kashmir to Kumaon.]

524. *Vanessa canace* (Johan.), Centur. Ins., p. 23 (1763) (Papilio) Bingham, FBI, 1 : 371 (1905).

*Kashmir. [Kashmir to Sikkim; S. India, Nilgiris; Mysore; Travancore; Assam; Burma.]

525. *Vanessa cashmirensis* Koll., Hugel's Kaschm., 4 : 422 (1844); Bingham, FBI, 1 : 367 (1905).
*Kashmir. [Kashmir to Sikkim.]

526. *Vanessa ladakensis* Moore, ANMH, (5) 1 : 227 (1878); Bingham, FBI, 1 : 368 ((1905).
*Ladak. [Chitral, W. Tibet; Nilang Pass. Sikkim; Chumbi Valley.]

527. *Vanessa rizana* Moore, PZS, p. 559 (1872); Bingham, FBI, 1 : 368 (1905).
*Kashmir. [Kashmir to Sikkim.]

528. *Vanessa vaualbum* (Densis & Schieff.), Vien. Verz. p. 176, (1776); (Papilio); Bingham, FBI, 1 : 369 (1905).
*Kashmir. [Chitral.]

529. *Ypthima huebneri* race *kashmira* Moore, JASB, p. 17 (1884) Bingham, FBI, 1 : 142 (1905).
N. W. Himalayas; *Kashmir. [S. India, Mysore; Anaimalai Hills.]

530. *Ypthima cerealis* Watson, JBNHS, 10 : 646 (1897); Bingham, FBI, 1 : 140 (1905).
*Kashmir, *Kulu. [Simla to Kumaon; Bengal; Orissa; Burma; Tenasserim.]

531. *Ypthima nareda* (Koll.), Hugel's Kaschm, 4 : 458 (1844) (Satyrus); Bingham, FBI, 1 : 138 (1905).
*N. W. Himalayas, *Kashmir [Kashmir to Kumaon.]

532. *Ypthima sakra* Moore, Cat. Lep. Mus. E. I. C., 1 : 236 (1857); Bingham, FBI, 1 : 137 (1905).
*Kulu. [Kulu to Sikkim; Assam; Khasi Hills; Upper Burma.]

Family LYCAENIDAE

533. *Cyaniris coelestina* Koll., Hugel's Kasch, 4 : 423 (1844); Bingham, FBI, 2 : 332 (1907).
*Kashmir. *Muree. [Simla; Mussoorie; Nainital.]

534. *Lycaena astrarche* Bergster, Nomencl., 3 : 49 (1779) (Papilio); Bingham, FBI, 2 : 337 (1907).
*Kashmir. [Chitral; Simla to Kumaon; Baluchistan.]

535. *Lycania devanica* Moore, PZS, p. 573 (1874) (Polyommatus); Bingham, FBI, 2 : 344 (1907).
*Kashmir; *Ladak.

536. *Lycaena galathea* Blanchard, Jacq., Voy. Ind., 4 : 28 (1844); Bingham, FBI, 2 : 348 (1907).
*Kashmir; *Kulu. Pangi [Chitral.]

537. *Lycaena hylas* (Wiener), Verzeis. p. 185 (1776) (Papilio); Bingham, FBI, 2 : 351 (1907).
*Kashmir. [Kumaon; Baltistan; Baluchistan.]

538. *Lycaena icarus* (Rotten.), Naturf., 6 : 21 (1775) (Papilio); Bingham, FBI, 2 : 339 (1907).
*Ladak. [Chitral; Baluchistan.]

539. *Lycaena omphisa* Moore, PZS, p. 573, pl. 66, fig. 2 (1874); Bingham, FBI, 2 : 347 (1907).
*Ladak; *Lahoul. [Chitral.]

540. *Lycaena orbitulus* race *jaloka* Moore, PZS, p. 573 (1874), pl. 66, fig. 3; Bingham, FBI, 2 : 349 (1907).
*Kashmir; *Ladak. Pangi.

541. *Lycaena pheretes* race *lehana* Moore, ANMH (5) 1 : 230 (1878); Bingham, FBI, 2 : 352 (1907).
*Ladak; Kashmir.

542. *Lycaena stoliczkana* Felder, Rovara Reise, Lep., 2 : 283 (1865); Bingham, FBI, 2 : 341 (1907).
*Kashmir. [Chitral.]

Family NEMEOBIDAE

543. *Dodona durga* (Koll.), Hugel's Kaschm., 4 : 441 (1844) (Melitaea); Bingham, FBI, 1 : 481 (1905).
*Kashmir. [Kashmir to Nepal.]

544. *Dodona dipaea* Hewitson, Butt., 3 : pl. 1, fig. 6 (1866); Bingham FBI, 1 : 482 (1905).
*Kulu. [Kulu to Sikkim; Bhutan; Assam; Naga Hills.]

545. *Dodona egeou* Doubleday, Hew. Gen. Di. Lep., 2: 422, pl. 69, fig. 2 (1851); Bingham, FBI, 1 : 484 (1905).
*Kashmir. [Kashmir to Bhutan; Assam; Khasi & Naga Hills.]

Order DIPTERA

ORTHORRHAPHA

Family CULICIDAE

1. *Aedes (Finlaya) christophersi* Edwards, Indian, J. med. Res., 10 : 267 (1922); FBI, Megarhini and Culicini 5 : 195 pl. III fig. 12 (1934).
*Kashmir : Gulmarg. *Murree. [W. Himalayas : Simla, Fagu, Krol. Mt. near Solan.]

2. *Aedes (Finlaya) psuedotaeniatus* Giles, JBNHS, 13 : 607 (1901); FBI, Megarhini and Culicini 5 : 178 pl. iii, fig. 10, pl. v fig. 4. (1934).
*Kashmir : Baltistan. [N. W. Frontier, Assam, Burma, Ceylon.]

3. *Aedes (Finlaya) pulchriventer* Giles, JBNHS, 13 : 601 (1901); FBI, Megarhini and Culicini 5 : 199 pl. iii fig. 4 (1934).
*Kashmir : Gulmarg. [Dungagali, Hazara Dist., Abbotabad, Sikkim border : Yatung, Tibet; Assam Hills : Chirrapunji ; Simla Hills.]

4. *Aedes (Finlaya) sintoni* Barraud, Indian J. med. Res., 2 : 967 (1924); FBI, Megarhini and Culcini 5 : 200 fig. 43 (1934).
   *Kashmir. *Murree.

5. *Aedes (Finlaya) shortii* Barraud, Bull. Ent. Res., 13 : 405 (1923); FBI, Megarhini and Culicani 5 : 183 pl. v fig. 2 (1934).
   *Kashmir : Gulmarg, Aru, Lidder Valley. [Assam : Shillong, Chirrapungi; Sumatra.]

6. *Aedes (Ochlerotatus) caspius* Pallas, Reise. versch. Prov. Russ. Reichs., 1 : 475 (1771); FBI, Megarhini and Culicini 5 : 148 (1934).
   *Kashmir : Baltistan, Bragica 7200 ft. [N. W. Frontier : Peshawar. Taru, Nowshera, Rawalpindi, Bannu, Chaman, Dera Ismail Khan. Also known from European coasts Central Europe and eastwards to Gobi Desert, North Africa, Persian Gulf and Mesopotamia.]

7. *Aedes (Ochlerotatus) pulchritarsus* Rondani, Bull. Soc. Ent. Ital., 4 : 31 (1872); FBI, Megarhini and Culcini 5 : 150 (1934).
   *Kashmir. [Southern Europe, Turkestan.]

8. *Aedes (Ochlerotatus) pullatus* Coquillet, Proc. ent. Soc. Washington, 6 : 168 (1905); FBI, Megarhini and Culuicini 5 : 152 & 442 (1934).
   *Kashmir : Gulmarg. [Central and South Europe and Western North America, Deosai Plain, Shingo river, Chota Deosai : 13500 ft, Tsurri, Indus Valley.]
   *Baltistan : 7700 ft.

9. *Aedes (Stegomyia) flavopictus* Yamada, Ann. Zool. Jap., 10 : 52 (1921); FBI, Megarhini and Culicini 5 : 239 (1934).
   *N. W. Himalayas : Murree 7000 ft. [Assam : Shillong 5000 ft. W. Himalayas : Kasauli and Krol Mt. near Solan 6000-7000 ft. S. W. India : Coorg, Mercara.]

10. *Anopheles annularis* Van der Wulp, Notes from the Leyden Museum, 6 : 249 (1884); FBI, Anophelini 4 : 300 fig. 51 (1933).
    *Kashmir. [Philippines, Formosa, S. China, Borneo, Lesser Sunda Islands : Soemba Timor. Java with Noesa Kambangan; Sumatra with Nias; Tonkin, Annam, Cochin, China, Malay Peninsula, Siam, Burma, Ceylon, Nepal.]

11. *Anopheles annularis (fuliginosus)* Christophers, FBI, Anophelini 4 : 346 (1933).
    *Kashmir. *Kangra. [Widespread.]

12. *Anopheles barianensis* James, Anop. mosq. India 2 : 76 (1911); FBI, Anophelini 4 : 117 fig. 20 (1933).
    *N. W. Himalayas : 5000-8000 ft. *Kangra Dist : Naggar and Sil Madhani. *Kashmir : Dal Lake, Srinagar. *Murree. [Barian, Kasauli, Punjab E & N : Amabla, Rawalpindi, Simla.]

13. *Anopheles culicifacies* Giles, EMM, (2) 12 : 197 (1901); FBI, Anophelini 4 : 197 fig. 32 (1933).
    *Murree 7500 ft. *Kashmir: Kohala. *Kangra. [Widespread.]

14. *Anopheles fluviatilis* James, Sci., Mem. Govt. India, 2 : 31 (1902) ; FBI, Anophelini 5 : 203 fig. 33 (1933.)
*Kashmir 6000 ft. *Murree 7500 ft. [Siam, Tonkin, Turkestan. Lower Burma : Akyab district. Baluchistan and the N. W. F. P. including Swat territory. Ceylon].

15. *Anopheles fluviatilis* (*listonii*), FBI, 4 : 350 (1933).
*Kashmir. *Kangra. [Widespread.]

16. *Anopheles gigas var. simulensis* (James), Anop. mosq. India, 2 : 66 (1911); FBI, Anophelini 4 : 136 (1933). [Patagiamia]
*Kangra : Manali 6000 ft., Rahla 8000 ft., Karaun. *Chamba : Bakloh 6000 ft. Bara Nullah. *Dalhousie. *Murree. *Kashmir Gulmarg 8500 ft. Nara Nag 7500 ft., Aran 8000 ft. [U. P : Kalighat in Garhwal 6000 ft., Banbassa, Dehra Dun 2000 ft., Roorkee, Bareilly, Saharanpur 2500 ft., Punjab : Simla 7000 ft., Mahasu 8000 ft., Kasauli 6000 ft., Dharmpur 4000 ft., Karnal. N. W. F. P : Abbottabad 4000 ft.]

17. *Anopheles gigas* (*including vars*) Christophers, FBI, Anophelini 4 : 350 (1933).
*Kashmir; *Kangra; [Assam : Cachar, Khasi and Jaintia Hills, Lakhimpur. Upper Burma : Yaung Hwe State. Ceylon. Hoshangabad; Palanpur State; Madras : Madura, Nilgiris. N. W. F. P : Hazara, Peshawar. Punjab : Ambala, Chamba, Gurdaspur, Karnal, Rawalpindi, Simla. U. P : Dehra Dun, Garhwal, Naini Tal, Saharanpur.]

18. *Anopheles hyrcanus var nigermus* Christophers, FBI, Anophelini 4: 350 (1933).
*Kangra. [Widespread.]

19. *Anopheles lindesaysi* Christophers, FBI, Anophelini 4 : 352 (1933).
*Kashmir. *Kangra. [Assam : Khasi and Jaintia Hills. Baluchistan : Quetta-Pishin. Bengal : Darjeeling, Jalpaiguri. N. W. F. P : Kohat, Peshawar, Swat Territory. Punjab, Ambala, Gurdaspur, Rawalpindi, Simla. Sikkim. U. P : Almora, Dehra Dun, Garhwal, Naini Tal. Waziristan, Bannu Area.]

20. *Anopheles maculatus var. willmori* James, Theo. Mono. Cul., 3 : 100 (1903); FBI, Anophelini, 4 : 285 fig. 47 (1933).
*Kashmir. [Widespread.] *Kangra.

21. *Anopheles splendicus* (*maculipalpis var idiensis*) Christophers, FBI, 4 : 355 (1933).
*Kashmir; *Kangra. [Widespread.]

22. *Anopheles stephensi* Christophers, FBI, 4 : 356 (1933).
*Kashmir. *Kangra. [Widespread.]

23. *Anopheles subpictus* Christophers FBI, Anophelini 4 : 356 (1933).
*Kangra. [Widespread.]

24. *Anopheles turkhudi* Liston, Indian. med. Gaz., 36 : 441 (1901); FBI, Anophelini 4 : 358 fig. 41 (1933).
*Kangra. *Murree 7000 ft. [Widespread.]

25. *Culex* (*Barradius*) *modestus* Ficalli, Bull. Soc. Ital., 24 : 93 (1890); FBI, Megarhini and Culicini 5 : 346 fig. 83 (1934).
*Kashmir : Jhelum Valley. [Asia Minor, Meaitterranean region and Spain.]

26. *Culex* (*Culex*) *mimeticus* Noe, FBI, Megarhini and Culicini 5 : 451 (1934).
*Kashmir : Nara Nag. [N. W. P : Bakloh. Assam : Shillong and Cherrapungi. Bihar : Pusa. Ceylon. Macedonia. Palestine. Tibbet : Yatjung. North China : Peking. South China : Nanking District, Hangchow, Kiangsi, Chekiang. Hong Kong. Formosa.]

27. *Culex* (*Culex*) *theileri* Theobald, M. C., 3 : 187 (1903); FBI, Megarhini and Culicini 5 : 414 fig. 98 (1934).
*Kashmir. [Western Himalayas. Punjab. N. W. Frontier. Baluchistan. Assam Hills. Burma. Hindu-Kush mountains 9500 ft. Mediterranean region extending to Atlantic islands westwards and through Mesopotamia to Persia eastwards. Found in East and South Africa].

28. *Culex* (*Culex*) *vagans* Wiedemans, Aussereuop. Zweifl. Ins., 1 : 545 (1828); FBI, Megarhini and Culicini 5 : 416 fig. 99 (1934).
*Kashmir. [Western Himalayas. N. W. Frontier. Punjab. Delhi. Eastern Himalayas. Southern and Eastern China and Siberia : Vladivostok.]

29. *Culex* (*Culiciomyia*) *viridiventer* Giles, JBNHS., 13 : 609 (1901); FBI, Megarhini and Culicini 5 : 378 (1934).
*Kashmir 5000-6000 ft. [Nepal. Assam. South India and Ceylon.]

30. *Dixa* (*Dixa*) *montana* Brunetti, RIM., 4 : 265 (1911); FBI, Megarhini and Culicini 5 : 433 (1934).
*N. W. Himalayas : Murree. [Simla district.]

31. *Dixa* (*Dixa*) *christophersi* Barraud, FBI, Megarhini and Culicini 5 : 435 (1934).
*Kashmir : Nara Nag 7500 ft. [Tibet : Yatung].

32. *Dixa* (*Dixa*) *platystyla* Barraud, FBI, Megarhini and Culicini 5 : 436 (1934).
*Kashmir : Nara Nag 7500 ft.

33. *Dixa* (*Dixa*) *sp.* Barraud, FBI, Megarhini and Culicini 5 : 434 (1934).
*Kashmir : Aran 8000 ft.

34. *Dixa* (*Paradixa*) *kashmirensis* Barraud, FBI, Megarhini and Culicini 5 : 437 (1934).
*Kashmir : Aran 8000 ft.

35. *Theobaldia longiareolata* Macquart, Dipt. Exot., 1 : 34 (1838); FBI, Megarhini and Culicini 5 : 88 (1934).
*Murree. [Bannu, Malakand, Taru in Peshawar, Cherat, Idak, Dera Ismail Khan, Quetta, Pishin, Chaman, Karachi, Kasauli, Sanawar, Naini Tal. Mediterranean region, Atlantic Islands, Persia, East and South Africa].

36. *Theobaldia niveitaeniata* (Theobald), M. C., 4 : 272 (1907) (*Pseudotheobaldia*), ; FBI, Megarhini and Culicini 5 : 91

*Murree. [Western Himalayas : Kasauli, Theog, Hindustan-Tibet road 8000 ft., Naini Tal, Muktesar. U. P : Dehra Dun. E. Himalayas : North of Yatung, Tibet, near Sikkim border 12000 ft.]

37. *Uranotaenia unguiculata* Edwards, J. Proc. Asiatic Soc. Bengal, (n. s.) 9 : 51 (1913); FBI, Megarhini and Culicini 5 : 67 (1934).
*Kashmir : Jhelum river, Wular Lake, Srinagar, Gunderbal. [Turkestan, Italy, Algeria, Egypt, Palestine.]

Family STRATIOMYIDAE

38. *Odontomyia kashmirensis* Brunetti, FBI, Brachycera, 1 : 67 (1920).
*Kashmir : Jhelum Valley, 5200 ft.

39. *Stratiomyia barca* Walker, List. Dipt. Brit. Mus., 3 : 530 (1849); FBI, Brachycera, 1 : 59 (1920).
*Kashmir : Jhelum Valley 5200 ft., Srinagar 6000 ft. [China].

Family NEMESTRINIDAE

40. *Hirmoneura opaca* Lichtward, p. 643 (1909); FBI, Brachycera 1 : 150 pl. ii fig. 22 (1920).
*N. W. Himalayas : Kangra Valley 4500 ft. [Mussoorie, Dehra Dun, Simla].

Family CYRTIDAE

41. *Pterodontia kashmirensis* Lichtwardt, p. 124 (1909). FBI, Brachycera 1 : 166 (1920).
*Kashmir : Kulu 5000 ft.

Family BOMBYLIIDAE

42. *Anthrax baluchianaus* Brunetti, FBI, Brachycera 1 : 250 (1920).
*Kashmir. [Baluchistan ; Bahist Khal; Bhittani.]

43. *Anthrax manifesta* Walker, Ins., Saund., Dipt., 3 : 178 (1852); FBI, Brachycera 1 : 242 (1920).
*Kashmir : Jhajjur. [Mussoorie; Simla; Lower Ranges of Khasi Hills.]

44. *Argyramoeba duvaucelli* Macquart, Dipt. Exot., 2 (1) : 63 pl. xx, fig. 7 (1840); FBI, Brachycera 1 : 225 pl. iii, fig. 13 (1920).
*Kangra valley, 4500 ft; *Murree Hills. [N. Bengal : Bhogaon U. P : Sahelwa; Bahraich Dist; Allahabad; Pusa; Lahore; Bengal : Dum Dum; Bihar : Chapra Purneah.]

45. *Exoprosopalar* (Fabricius) Sp. Ins., 2 : 414 (1781) (*Bibio*); FBI, Brachycera 1 : 194 pl. iii, fig. 3 (1920).
*Kangra valley. [Bara Banki; Allahabad; Bandhara; Sahibganj; Bellary; Surat; Bangalore; Trivandrum; Ceylon : Mahagany, Nilavelli].

46. *Systoechus socius* (Walker), Ins. Saund., Dipt., 3; p. 201 (1852); (*Bombylius*) FBI, Brachycera 1 : 276 (1920).
*Kashmir *Kangra valley, 4500 ft. [Dehra Dun; Theog; Simla Hills; Bhowali Sikkim : Runjit valley Coimbatore. Ceylon : Hadagalli.]

CYCLORRHAPHA

Family SYRPHIDAE

47. *Ceria brevis* Brunetti, FBI, Syrphidae etc. 3 : 328 (1923).
*Kashmir 5000 ft.

48. *Ceria dimidiatipennis* Brunetti, FBI, Syrphidae etc. 3 : 329 (1923).
*Kashmir, 5000-6000 ft. [N. W. F. P : Hangu, Abbotabad. Baluchistan : Quetta].

49. *Chrysogaster* (*Orthoneura*) *indica* Brunetti, RIM, 11 : 203 (1915) ; FBI, Syrphidae etc. 3 : 40 fig. 10 (1923).
*Kangra Valley 4500 ft.

50. *Criorrhina imitator* Brunetti, RIM, 11 : 236 pl. xiii. fig. 14 (1915); FBI, Syrphidae etc. 3 : 283 fig. 54 (1923).
*Kashmir 8000-9000 ft. [Onari, Andarban. Garhwal Himalayas : 11000 ft.]

51. *Criorrhina vivida* Brunetti, FBI, Syrphidae etc. 3 : 285 (1923).
*Kashmir. [Eastern Himalayas : Runjit Valley in Sikkim.]

52. *Eristalis arbustorum* (Linnaeus), Syst. Nat. Ed., 10 : 591 (1758) (*Musca*); FBI, Syrphidae etc. 3 : 179 (1923).
*Kashmir. [Europe, North Persia, Siberia and North Africa].

53. *Eristalis obscuritarsis* de Meijere, Tijd. v. Ent. 51, p. 250, pl. vii, figs. 19, 20 (1908); FBI, Syrphidae etc. 3 : 190 pl. iv, figs. 15-18. (1923).
*Kashmir. [Bangalore, Chittagong, Deesa, Singapore, Bombay.]

54. *Eristalis sepulchralis* (Linnaeus), Syst. Nat. Ed., 10 : 596 (1758); (*Musca*) FBI, Syrphidae etc. 3 : 161 pl. iv, fig. 3 (1923).
*Kashmir. [China : Hankow & Shanghai. Europe].

55. *Eumerus albifrons* Walker, Ins., Saund. Dipt., 1 : 224 (1852); FBI, Syrphidae etc. 3 : 257 pl. vi, fig. 4 (1923).
*Kangra Valley 4500 ft. [Puri, Coimbatore].

56. *Syrphus fulvifacies* Brunetti, RIM, 8 : 161 (1913); FBI, Syrphidae etc. 3 : 89 (1923).
*Kashmir 8000-9000 ft. [Rotung.]

Family CONOPIDAE

57. *Myopa nigriventris* Brunetti, FBI, Syrphidae etc., 3 : 380 (1923).
*Kashmir : 5000-6000 ft. [Mussoorie.]

58. *Myopa testacea* (Linnaeus), Syst. Nat., 11 (2) : 1006 (1759); (*Conops*) FBI, Syrphidae etc., 3 : 381 (1923).
*Kashmir : 5000-6000 ft. [Northern Africa ; Europe].

59. *Physocephala rufesceus* Brunetti, FBI, Syrphidae etc. 3 : 360 p. l. vi, fig. 11 (1923).
*Kashmir : 5000 ft.

60. *Physocephala tenella* (Bigot), Ann., Soc., Ent. France, (6) 7 : 35 (1887) (*Conops*); FBI, Syrphidae etc. 3 : 366 (1923).
*Kangra valley : 4500 ft. [Coimbatore ; Singapore; Ceylon; Quetta.]

Family CALLIPHORIDAE

61. *Calliphora pattoni* Aubertin, AMNH (10) 8 : 615, (1931); FBI, 6 : 38 fig. 14 (1940).
*Kashmir. [Darjeeling; Khasi Hills; Mishmi Hills; Dalai Valley 4000-8000 ft; Burma].

62. *Lucilia porphyrina* (Walker), J. Proc. Linn. Soc. London, 1 : 24 (1857) (*Musca*); FBI, 5 : 53 fig. 25 (1940).
*Kashmir : Gulmarg. [Kasauli, 6000 ft; Assam; Mishmi Hills; Dalai valley, 5000-6000 ft; Ceylon; Malay Peninsula; China : Hong Kong; Swatow; Krakatoa; Sebsi; Sumatra; Java; Philippine Islands; Japan; Tsu Shima; Australia : Queensland, Brisbane.]

63. *Pollenia rudis* (Fabricius), Ent. Syst. 4 : 314 (1794) (*Musca*); FBI, 6 : 117 figs. 56, 57, 58 (1940).
*Kashmir. [Waziristan and Chitral.]

64. *Sarcophaga albiceps* Meigen, Syst. Besch., 5 : 22 (1826); FBI, 6 : 242 fig. 120 (1940).
*Kulu. [Palaearctic region : Europe, Palestine, North China. Oriental Region : Abbotabad, throughout India including hills up to 6000 ft. Ceylon, Burma, Tong-king, Formosa, Sumatra, Java, Lombok. Australian Region : New Guinea.]

65. *Sarcophaga dux* Thomson, Dipt. Eugen. Reise., p. 540 (1868); FBI, 6 : 266 (1940).
*Kashmir . [Europe; Mesopotamia; East Bengal; Nilgiri Hills; Ceylon; Java; Bali; Philippine Islands; Formosa; Queensland; Guam; Hawaii; Hainan; Canada; Manitoba; United States; Seychelles Islands.]

66. *Sarcophaga haematodes* Meigen, Syst. Beschr., 5 : 29 (1826); FBI, 6 : 225 fig. 103 (1940).
*Kashmir. [Darjeeling].

67. *Sarcophaga haemorrhoidalis* (Fallen). Vet. Akad. Handl., p. 237 (1816) (*Musca*); FBI, 6 : 276 fig. 151 (1940).
*Kulu. [Palaearctic Region : Europe, Palestine, Iraq, Persia, Seistan, China. Oriental Region : Darjeeling, Plains at Siliguri at the foot of the Darjeeling Terai. Ethiopian Region : South Africa, Seychelles, Rodriguez. Nearctic Region : Widely distributed. Also recorded in North America and Montana.]

68. *Sarcophaga khasiensis* Senior-White, RIM. 26 : 246 (1924); FBI, 6 : 255 fig. 133 (1940).
*Kashmir. [Khasi Hills.]

69. *Sarcophaga melanura* Meigen, Syst. Beschr., 5 : 23 (1826); FBI, 6 : 222 fig. 99 (1940).
*Kashmir. [Formosa; China; Japan.]

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

PART XIII.—SECOND ENTOMOLOGICAL EXPEDITION TO THE NORTH-WEST (PUNJAB) HIMALAYAS (1955)

By M. S. MANI, M. A., D. SC., F. R. E. S., F. L. S., *Professor of Zoology & Entomology*, and SANTOKH SINGH, M. SC., *Research Associate, School of Entomology, St. John's College, Agra.*

I. INTRODUCTION

The Second Entomological Expedition to the North-west (Punjab) Himalayas spent nearly six weeks during May and June 1955, collecting and studying the high altitude insect life in Lahaul-Spiti. The team comprised, in addition to the authors, Messrs H. N. Baijal, V. K. Gupta and M. Visvanath from the School of Entomology, Mr. R. V. Charley, Lecturer in Chemistry, St. John's College and Major E. A. Vas of the Indian Army, 9th Gurkha Rifles, The Infantry School, Mhow. The Government of India attached to the Expedition Dr. A. P. Kapur of the Zoological Survey of India, Ministry of Scientific Research and Natural Resources. According the original plan, the Expedition expected to establish the supply base at about 15,000 ft above mean sea level on Kanzam La in the Spiti Border by about the 10th of June 1955. The route was in part the same as in 1954, but beyond the Rohtang Pass the trek was eastward to the Bara Shigri Glaciers, thence north to the Kanzam La Pass. The Expedition left Agra on May 18, 1955, with nearly a ton of stores of equipment and food and reached Manali at the end of Beas Valley. Unexpected and unusually late snow fall however held up the party at about 9000 ft., on the south side of the Rohtang Pass for several days and thus considerably upset the programme. Even after crossing the Rohtang pass considerably behind schedule and reaching Lahoul, continued bad weather forced us to give up the plan of Kanzam La supply base. It was also not possible to reach the Bara Shigri Glaciers. In the race against time and fast diminishing supplies, it was decided to establish the supply base somewhat below 13,000 ft. in an alpine meadow above the River Chandra, overlooking the Kulti Nal Glaciers. After overcoming numerous difficulties, essential supplies were pushed on to an advance camp below the Ice Fall Mountains of the Purana Khoksar Nal.

While not specially organized for spectacular feats of peak conquerings, the Expedition actually climbed a number of unnamed and unconquered peaks in search of high altitude insects. Although continued bad weather forced us to greatly curtail our original programme, the Expedition was however successful in making large collections of many rare and extremely interesting specimens. Over 5000 specimens of adults and much larger numbers of larvae were collected.

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*Contribution No. 66 from the School of Entomology

Some of the specimens were taken at altitudes never before reached by an entomologist in this part of the Himalayas.

In addition to collecting specimens, opportunity was also used for studying the various conditions under which the high altitude insects thrive. Temperature, pressure, wind, light, velocity of the currents in the torrential streams, oxygen dissolved in the torrential waters, food resources, shelter, etc. are some of the more important factors recorded. Observations were also made on the habits, peculiarities of life-cycles and the inter-relationships of the insects. Although collections were made almost continuously from about 5000 ft. upwards, our main object was the study of the insect life at extreme altitudes beyond the limits of tree-growth, between 12,000 ft. and 18,000 ft. above mean sea level.

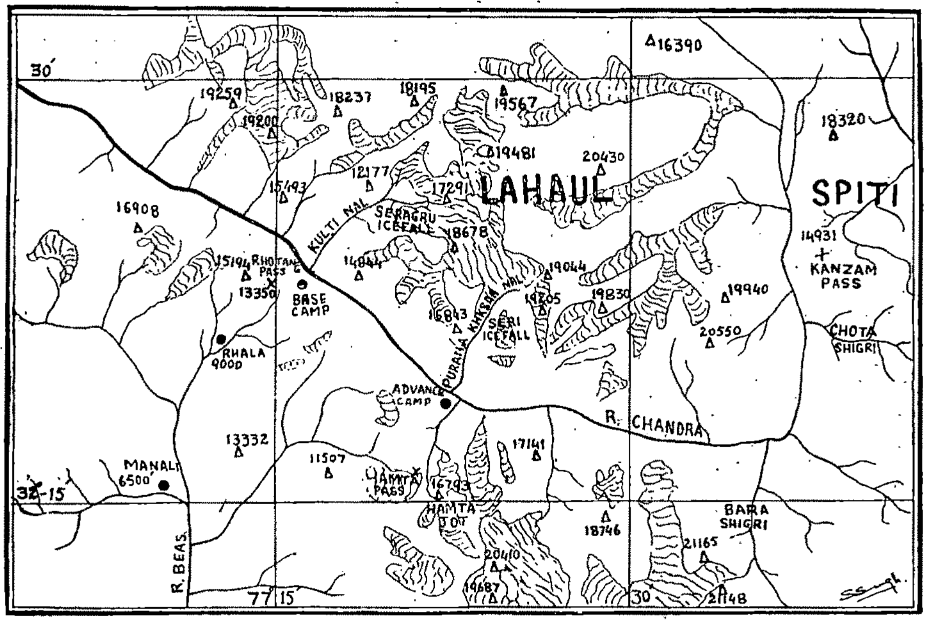

FIG. 1. Sketch map of Lahaul-Spiti, showing River Chandra, the larger torrential streams, the chief glaciers and the more important peaks. The camp sites of the Expedition are also indicated.

All field notes and records of ecological observations were made on specially printed and standardised Cardex (supplied by Remington Rand Inc.). These notes are now serially numbered and filed in the Laboratory of the School of Entomology, pending permanent deposit, together with the collections, in the Zoological Survey of India. Field descriptions of the Stations were supplemented by diagrammatic sketches and photographs. Most of the larger specimens have since been microfilmed for permanent record.

The first author made several hundred feet of 35 mm kodachrome close-up photographs of the high altitude flowers and insects in their natural surroundings. He also shot a 16 mm colour movie film, recording the various activities of the Expedition and showing some of the typical ecological conditions.

The collections have now been sorted out, permanently labelled and indexed as a preliminary to study by various specialists. It will be some time before the material is worked out and the full details of the work of the Expedition can be published. These preliminary notes on some interesting aspects of the high altitude insect life of the North-west Himalayas and of the peculiar conditions under which the insects flourish are published here merely with a view to focuss the attention of workers on the study of high altitude insects.

II. LAHAUL-SPITI

North-West Himalayas (Fig. 1), bounded by the river Sutlej in the east and Indus in the west, comprises part of Kashmir, Ladakh, Lahaul & Spiti. It may be considered as part of the South-western edge of the Tibetan plateau. In Lahaul are the upper reaches of the River Chenab, formed by the confluence of Chandra and Bhaga below Tandi at about 10,000 ft above mean sea level, four miles west of Keylang. Chandra has its source near Baralacha La (16,200 ft). After flowing west of Kanzam La (14, 931 ft.) for nearly 50 miles, it bends abruptly to the west, near the Bara Shigri Glaciers. From here it follows an almost straight course to the confluence. Bhaga has it source also near Baralacha La but on the northern slopes of the mountains and descends to 14,000 ft. near Zinzingbar Serai. The Spiti river, a tributary of Sutlej, drains an extensive region to the east of Kanzam La. The general elevation of Lahaul-Spiti is never below 10,000 ft. and several peaks rise to elevations between 19,000 and 21,000 ft. While the major rivers probably belong to the antecedent river system characteristic of the Himalayas in general, the torrential streams in this region are undoubtedly of comparatively recent origin. Though within the fringe of the Palaearctic, the region is separated from the tropical of India by only a short distance. Lahoul-Spiti represents the meeting point of the Palaearctic of Tibet and Oriental of India. The boundaries between these faunal divisions are not always sharply defined but more or less intergrade especially in the narrow gorges and valley running south-north. Owing to the higher latitude than in the other parts of the Himalayas, the permanent snow line is also much higher.

DESCRIPTIONS OF STATIONS

Collections and observation were made in a great variety of habitats and micro-climatic niches, representing variations in elevations from about 5000 ft. to nearly 17,000 ft. above mean sea level (Fig. 2). The stations are distributed on the summits of mountains, slopes both northern and southern, narrow gorges and valleys, barren rocks and boulders, damp moss-covered rocks, under stones, underground shelters, rivers, glacial torrential streams, snow fields and glaciers. Altogether 42 stations are serially numbered and described here. The Station numbers, indicated by the circled figures on the maps in figs. 3-6, are also given in the labels attached to the specimens.

Station : 1. Torrent below Old Manali Village, at the end of Solang Valley, near the wooden bridge on Solang Stream. Under submerged boulders and stones, covered by alagal slime Current fast. Deodars and spruce on the slopes of the hills nearby. Altitude 6500 ft.

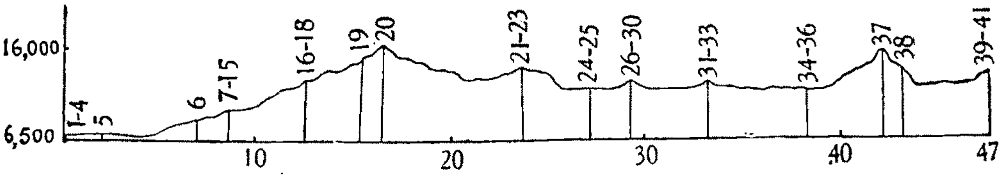

Fig. 2. Vertical section of of the route followed by the Second Entomological Expedition from Manali, a distance of nearly 47 miles shown on the horizontal axis. The altitudes are indicated on the vertical axis. The number 1-41 are Stations

Station : 2. Willow plantation in the compound of the Forest House in Manali, near a slow stream, at a short distance from the right bank of River Beas. Altitude 6500 ft.

Station : 3. Plantations of willow and *Alnus nitida* on the right bank of Beas, one mile south of Manatli Post and Telegraph Office on the Manali-Kulu Motor Road. Forest floor with dense growth of stinging nettles and some wild barberry. Altitude 6400 ft.

Station : 4. Slopes of hills on left bank of Beas opposite Manali and about half mile north of Manali bridge on the Manali-Kote Mule Track up to Basisht sulphur spring, covered by *Alnus,* poplar, elm etc. Altitude 6600 ft.

Station : 5. Meadow with a hill to the east on the left bank of Beas, one mile south of the Manali bridge on he Manali-Hamta mule track, with cultivated farms. Nettle growth. Altitude 6500 ft.

Station : 6. Nulla beneath a craggy spur and to the south-east of Kote PWD Rest House, running north-south, covered by ferns etc. Cultivated fields nearby. Conifers higher up. Altitude 7500 ft.

Station : 7. Camping Ground near the wooden bridge, slightly to the east of it, on the left bank of Beas, about half a mile to the west of Rahla Forest Inspection Hut. Covered by large stones and sheep dung and fallen leaves; damp, shady; with a slow stream on the south, below a hill slope covered by broad-leaved trees. Marsh marigolds, buttercups, potentillas flowering. Altitude 8800 ft.

Station : 8. Camping Ground opposite Station 7 on the right bank of Beas. Sloping meadow and largely exposed, sunny and relatively dry. Ground stony. On the north with a rocky wall. Water fall and a slow running stream cutting the meadow through into an east and west portion. Treeless. With the ledges in the rocky wall covered by damp moss. Altitude 8800 ft.

Station : 9. Shallow pond fed by escape from a waterfall at the foot of the rocky wall, below the wooden bridge on torrent near the Rahla Forest Inspection Hut. Shaded and with dim light. Protected from wind. Altitude 8835 ft.

Station : 10. River Beas near Rahla Forest Inspection Hut, with large boulders and stone. Current very fast, clear during the night, morning, fore-noon and most part of after-noon but often more or less turbid later. Exposed to direct sun during the mid day. Altitude 8835 ft.

Station : 11. Slopes below alpine meadow south of the Rohtang Pass about half a mile by the short-cut track from the Rahla Forest Hut. With large boulders, torrential streams, moss

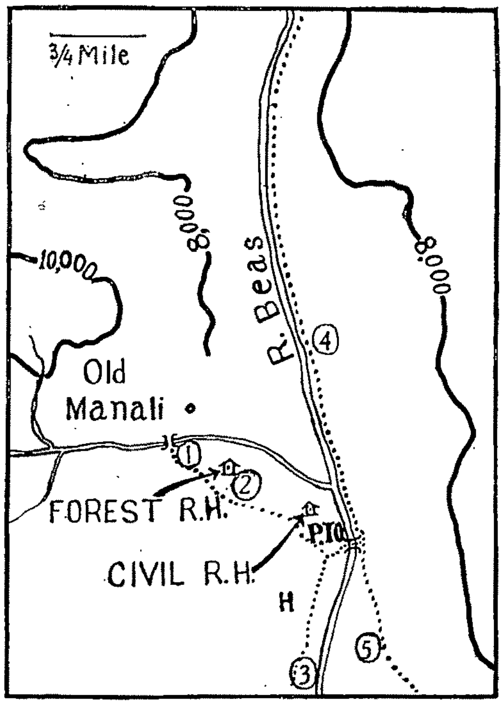

Fig. 3. Sketch map of Manali and environs. In this and in the following sketch maps, the numbers within circles refer to Stations. Some of the chief contour lines are also shown. Number of Stations: 1-5.

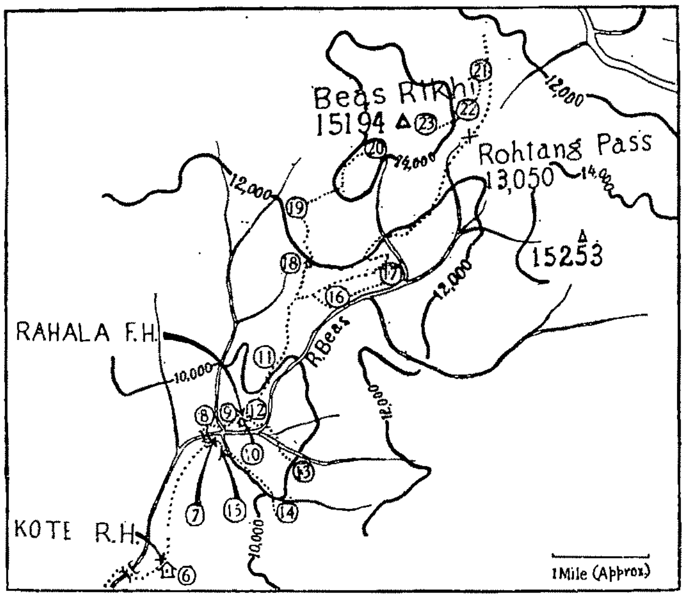

Fig. 4. Sketch map of the region near source of River Beas, showing Rahla, Rohtang Pass and the Beas Rikhi Peak. Number of Stations: 6-23.

A large cave used by sheep and shepherds, with the floor covered by filth and sheep dung. Exposed and windy during most of the time. Altitude 9500 ft.

STATION : 12. Grassy meadow to the east of the Rahla Forest Inspection Hut on the right bank of Beas, near its sharp curve from the north-south course to east-west. Sloping to the south gently towards the river and exposed and windy for a great part of the time. Grazing ground for sheep. Altitude 9000 ft.

STATION : 13. Snow line on rocky precipice at the curve of river Beas, western aspect, on southern spur from the east of Rohtang Pass, covered with dwarf birch still under several feet of snow. High altitude bush rhododendrons sparse. Altitude 10,500 ft.

STATION : 14. Meadow on a ridge on the left bank of river Beas, opposite Rahla Forest Inspection Hut, with subalpine vegetation all round. Torrential stream runs through the meadow down to the river. Exposed and windy. Altitude 10,500 ft.

STATION : 15. Sheltered cave, about 5 ft. in diameter and 8 ft. deep on rocky wall facing north, above river Beas, somewhat to the south-west of the Rahla Forest Inspection Hut. Damp and moss covered. A few ferns. Altitude 9500 ft.

STATION : 16. Right bank of river Beas near its source, just below the Rohtang Pass, with large boulders and stones. Primulas at the edges of the receding snow. Exposed, bright and sunny, high glare, windy. Altitude 11,000 ft.

STATION : 17. Snow covered and frozen bed of river Beas below the Rohtang Pass. Exposed. Glare very high. Strewn with blocks of snow brought by a recent avalanche. Altitude 11,200 ft.

STATION : 18. Alpine meadow in several terraces at the point of bifurcation of the mule track to Rohtang and the foot path to the frozen lake. Facing south. Exposed and extremely windy. Snow cover heavy and still largely persisting. Primulas and other low flowers at the edge of the snow. Numerous torrents and slow streams from the melting snows. PWD Gang Hut to one end. Altitude 12,300 ft.

STATION : 19. Windy and exposed meadow above Sta. 18 on way to the frozen lake, beneath the shadow of a peak to the north-east. Ground stony and extensive snow bed, hardened at places into ice. Small glacial streams. Altitude 12,000 ft.

STATION : 20. Snow covered summit of a mountain overlooking Sta. 18 & 19 and to the south of the Beas Rikhi Peak, somewhat east of Sta. 19. Windy. Glare high. Air temperature in the open at 1 P. M. on May 31, 1955 was 2°C in bright sunshine. Altitude 15,194 ft.

STATION : 21. Summit of Rohtang Pass near the camp at base of Beas Rikhi Peak and close to the northern edge of the pass. A vast desert of snow. Windy. Exposed. High glare. Altitude 13,300 ft.

STATION : 22. Rohtang. Rocky boulder left bare of snow, at base of Mt Beas Rikhi. Moss and lichen covered. Exposed and windy. Altitude 13,350. ft.

STATION : 23. Mt. Beas Rikhi, eastern slopes. Boulder exposed from snow, covered by moss and lichen, dwarf juniper. High glare. Altitude 14,500 ft.

STATION : 24. Gramphu Camping Ground on alpine meadow on left bank of River Chandra below Rohtang Pass a little to the west of opposite the Kulti Nal. 3 miles east of Khoksar. 500 ft. above the river bed. Numerous glacial torrential streams. Alpine flowers, especially primulas and buttercups. Altitude 11,000 ft.

STATION : 25. Slope below the Rohtang about 1 mile to the east of Sta. 24, with boulders and alpine flowers. Exposed and windy. Numerous torrential streams. North aspect. Altitude 11,200 ft.

STATION : 26. Slope about 2 miles east of Sta. 25. North aspect. Bush rhododendrons, dwarf juniper and birch. Snow line. Steep. With numerous torrents. Altitude 12,000 ft.

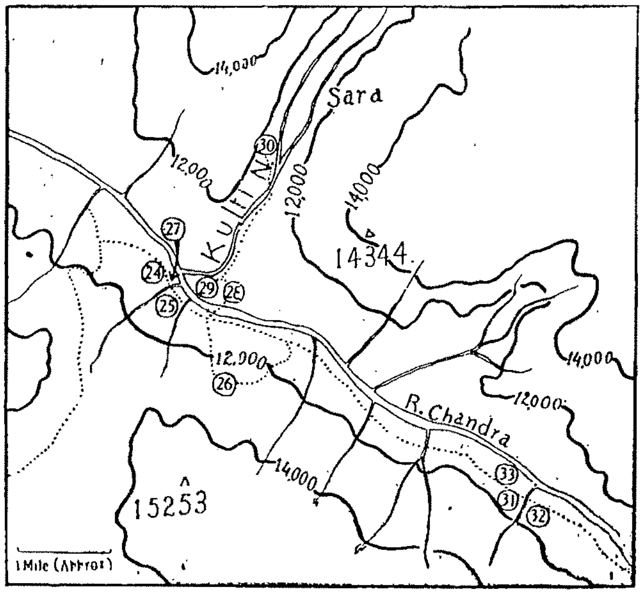

Fig. 5. Sketch map of the Kulti Nal area, with Stations 24-33.

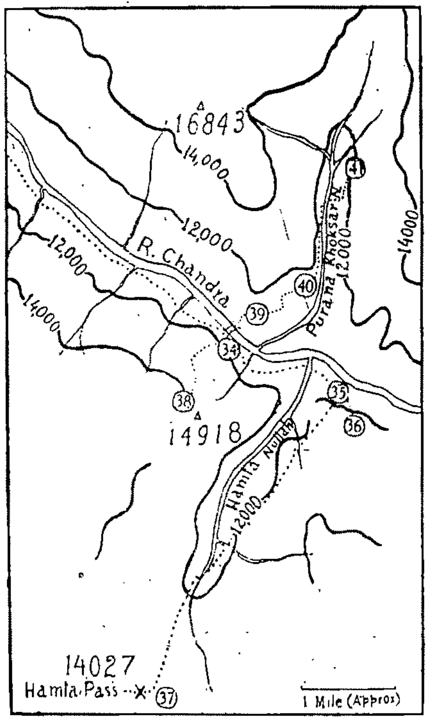

Fig. 6. Sketch map of the Purana Khoksar Nal area, with Stations 34-41.

STATION : 27. River Chandra below Sta. 24 and 25. Stony, sandy in places. Torrential and turbid water, with floating blocks of snow. Altitude 10,500 ft.

STATION : 28. Meadow near mouth of Kulti Nal and on the right bank of River Chandra, east of a sloping ridge. Camping Ground. Alpine flowers and torrential streams. Altitude 10,800 ft.

STATION : 29. Meadow to the west of Sta. 28 at the mouth of Kulti Nal. Similar to 28, but with some stagnant water.

STATION : 30. Kulti Nal, just beneath the snow line to the left of the torrent while ascending. Large stones. Barren. Altitude 11, 600 ft.

STATION : 31. Dhorni Camping Ground 5 miles east of the Gramphu Camping Ground on the left bank of River Chandra. PWD Gang Hut. Barren and exposed. Snow cover still persisting. Littered with avalanche debris. Altitude 12,000 ft.

STATION : 32. Slopes 1 mile east of Sta. 31 Alpine flowers at edge of the snow. Altitude 12,000 ft.

STATION : 33. River Chandra near Sta. 31. Alpine flowers opposite a rocky wall. Stony and sandy in patches. Altitude 11,500 ft.

STATION : 34. Sandy and stony meadow at Chandra level, opposite the site of the new bridge, on the let bank of Chandra, 5 miles east of Sta. 31 and 1 mile west of the Hamta Gorge, somewhat to the west opposite the Purana Khoksar Nal, with a rocky precipice on the south and a glacier on west. Sunny and warm. Ground littered with avalanche dedris. Shepherds camping ground. Altitude 11,000 ft.

STATION : 35. Shepherds' camping ground on grassy and sloping meadow on the left bank of River Chandra at the entrance to Hamta Gorge, 1 mile east of Sta. 34. Exposed. With large boulders and stones. Numerous glacial torrential streams. Altitude 11,200 ft.

STATION : 36. Snow covered mountain side bordering the sloping meadow of Sta. 35, with part of the barren rock free of snow near the summit, north aspect, exposed. About one and a half miles from the camping ground in Sta. 35. Altitude 12,500 ft.

STATION : 37. Snow fields on northern aspect of Hamtajot, a few boulders free of snow, covered by lichen and moss. 5 miles south of Sta. 34 and to the east of Hamta Pass. Altitude 14,500 ft.

STATION : 38. Snow fields on an uncharted narrow pass at about 14,000 ft. above sea level, to the south of Sta. 34, reached by way of the glacier described in Sta. 34, with peaks on either sides rising to about 16,000 ft. Boulders left bare of snow covered lichen and moss.

STATION : 39. Extensive alpine meadow on right bank of River Chandra at entrance to Purana Khoksar Nal, opposite Sta. 34 and about 50 ft. above river, with torrents running through. Camping ground with PWD Rest House. Altitude 11,000 ft.

STATOIN : 40. Purana Khoksar Nal, nearly one-half mile from Sta. 39, with torrential stream. Boulders and larger stones. Altitude 11,200 ft.

STATION : 41. Site 2 miles up from the entrance in the Purana Khoksar Nal, with pair of rocky abutments from the east and west, with torrential meandering stream in between. Barren rock. Just beneath the Ice Fall Mountain of Seri. Altitude 12,500 ft.

STATION : 42. Katrain. Willow plantation and cultivated field of potatoes, on right bank of Beas, opposite the Katrain Trout Research Station. Altitude 5500 ft.

IV. NOTES ON THE GENERAL CONDITIONS BEYOND THE TREE-LIMITS

Although the general conditions of life at high altitudes are fairly well known, a brief review of the more important factors influencing the insect life in the zone above the tree-growth limits in the North-West Himalayas should prove extremely useful.

The insect life of any region is more or less greatly influenced by the vegetation, which in turn is generally determined by the conditions of climate and soil. In the Himalayas however the effects of climate, soil and vegetation on the occurrence and abundance of insects are very profoundly modified by altitude. As we pass from one elevation to another, we find the plant and insect lives arranged in horizontal zones. These zones are not however sharply defined everywhere, but often tend to intergrade. High altitude also appears to have nearly the same effects as high latitude, so that the timber-line conditions in the north-west Himalayas between 10,000 and 12,000 ft. are very greatly similar to the prevailing conditions of vegetation at sea level near the Arctic Circle. Beyond the tree limits the conditions of life are extremely severe both for plants and animals. There is but little soil. The rock is generally covered by pioneer plants like lichen and moss, which break up the rock and build soil and humus. Erosion carries only a small part of the soil and humus thus formed. In the narrow spaces between rocks, sufficient soil and humus accumulate to support different kinds of characteristic plants and also provide optimum conditions for an amazing variety of insects. The great majority of the plants that grow in this zone are typically dwarfs and perennials, with hard woody underground mats, basal leaves and flowers. When the spring comes with a lush and the prolonged snow cover starts melting in late June, the dormant plants burst forth into life and shoots of new growth erupt with buds all ready to open.

Unlike in the rest of the Himalayas, owing to the relatively higher latitude the general conditions in Lahaul-Spiti are typical of Tibet, characterised by great aridity, frequent fierce cold winds, etc. The winter snow cover is however comparatively heavy. Spring comes later and the summer is shorter than at the same elevations in the rest of the Himalayas. Even in mid-summer the maximum air temperature is generally rather low. At a moderately high altitude of 15,000 ft. above mean sea level, the maximum air temperature in the open is often as low as 2°C. High glare and great ultra-violet radiations are among the other prevailing adverse conditions. The intense cosmic ray bombardments should also be considered among the major factors, though their precise effects are not perhaps fully understood. While the thinness of the atmosphere, the reduced atmospheric pressure and the increasing oxygen deficiency seem to have but little effect on the high altitude vegetation, at least not to such an extent as the cold and snow cover at great altitudes, their influence on the insect life taken as a whole seems to be more or less pronounced. Due to the reduced atmospheric pressure, the generally high wind velocity, and the low air humidity, the rate of evaporation from exposed surfaces is also extremely high.

Owing to the extreme atmospheric conditions prevailing at high altitudes and the relatively higher latitude, even very slight differences of micro-climatic effects are generally greatly exaggerated. Irrespective of the external atmospheric and altitudinal conditions, a wide range of micro-climatic niches, each with optimum conditions of temperature and humidity for specific types of insects occurs throughout the region. The temperature under stones or underground may often be 10-12°C higher than the prevailing air temperatures. The atmospheric conditions therefore do not always provide satisfactory clues to the temperature on barren and exposed rock surface or under stones. Local conditions so very profoundly modify the effects of altitude that extreme aridity occurs within a few feet of great dampness. Micro-climatic conditions differ widely on rocks, snow fields, glaciers, glacial torrential streams, caves and underground. The prevailing conditions on the snow fields include the low temperature, high glare, absence of cover, high wind velocity and relative scarcity of food. Stones and rock covered by snow normally are not greatly influenced by external conditions. The exposed rock presents considerably dry surface. The surface temperature of such rock during the hours of sunshine often rises to about 30°C and is therefore very much higher than the prevailing air temperature at the time nearby. Radiation of heat from the warm surface of the rock is naturally rapid and diurnal temperature changes great. The vegetation cover is extremely scanty and comprises patches of lichen and an occasional moss. Damp-moss-covered rock and submerged stones in the torrential streams provide much more uniform conditions of temperature for a greater variety of insects. Unlike in the Central and Eastern Himalayas, the torrential streams in this region are entirely of glacial origin and are not rain-fed. The temperature of these streams between 17,000 ft. and 10,000 ft. lies between 1.5°C and 4.5°C, while the prevailing atmospheric temperature may fall below 4°C. It is only when the streams have descended below an elevation of about 9000 ft. that their temperatures rise appreciably and often reach to about 10°C. Furthermore, the torrential streams are also comparatively rich in dissolved oxygen and air bubbles. The food resources are also relatively rich and varied in the shape of algal slime, smaller larvae and a variety of organic debris. The chief adverse conditions in the torrential streams include the difficulty that attends locomotion and maintenance of constant spatial relations with the surroundings, constant impact of moving water and of the objects that it carries.

Owing to the absence of trees and the restriction of the period of growth of even the dwarf vegetation to the extremely short summer, there is a great scarcity and general lack of variety of food. Among the various biotic factors, the prevailing over-crowding of large numbers of individuals of various types during the major part of their development appears to be the most important.

We may therefore by way of recapitulation note that the conditions beyond the limits of tree-growth are generally extreme, viz. low atmospheric pressures, temperatures and humidities, high wind velocities, intense sun light, glare and reflection from the snow surface, etc. The general effects of these extreme conditions are however often very profoundly modified and more or less greatly obscured by local conditions. The external factors due to mere latitude and altitude do not always relate to the insect types and their habits at any given altitude. Numerous small and localised islets of optima, common for a great many types of insects, are surrounded by vast stretches of extremely adverse conditions. These optima islets become fewer and fewer as we ascend higher to, about 18,000 ft.

V. NOTES ON THE GENERAL FEATURES OF THE HIGH ALTITUDE INSECT LIFE BEYOND THE TREE LIMITS

As reported earlier,[1] the variety and abundance of the insect life as whole fall off rapidly beyond the limits of tree-growth, which lie at 12,000 ft. in the outer and 10,000 ft. in the inner ranges. The zone immediately above these limits is certainly not barren; insect life is sparse but not absent. Different kinds of insects habitually occur at extreme altitudes, reaching to nearly 20,000 ft. above the mean sea level. Almost every Order of insects with which we are familiar in the plains of India, also occurs in this regions, but the genera and species are nearly in all cases different. Superficially the insect fauna of the region presents certain alpine facies, but closer examination reveals affinities to the Palaearctic of Tibet and Central Asia rather than to the European Palaearctic. There seems to be evidence, which will be discussed on a later occasion, to show that the insect fauna of the North-West Himalayas represents, at least in part geogrophical relicts of the Pleistocene of Asia.

In order to understand the peculiarities of the insects occurring at extreme altitudes, it would be necessary to examine, at least in brief outline, the insect fauna of the comparatively lower elevations also. As the collections brought back by the Second Entomological Expedition were made chiefly beyond an elevation of 6000 ft., we may consider the following altitude zone :—

Zone I. between 6000 ft. and 8000 ft.
Zone II. between 8000 ft. and 10,000 ft.
Zone III. between 10,000 ft. and 12,000 ft.
Zone IV. between 12,000 ft. and 14,000 ft. and Zone V. from 14,000 ft. reaching to between 20,000 ft. and 21,000 ft.

These zones correspond roughly to the well known sub-divisions, viz. the submontane, montane, subalpine, alpine and arctic.

The general abundance of the more important Orders in the 5 altitudinal zones is shown in figs. 7-11. As in the plains and foot-hills of the Himalayas,

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[1] MANI, M. S. 1955. *Agra Univ. J. Res. Res. (sci.)* 4 (1) : 157

Coleoptera is the dominant order between 6000 and 8000 ft. and is extremely abundant both as species and as individuals and almost outnumbers all other Orders. Nearly one-third of the insect population of this belt during May and June is Coleoptera. Almost all the families occurring in the plains are represented and in nearly same proportion. Chrysomelidae, Curculionidae, Elateridae, Rutellidae, Cetonidae, Scarabaeidae and Coccinellidae constitute the more important types. Carabidae and Staphylinidae occupy only a minor place.

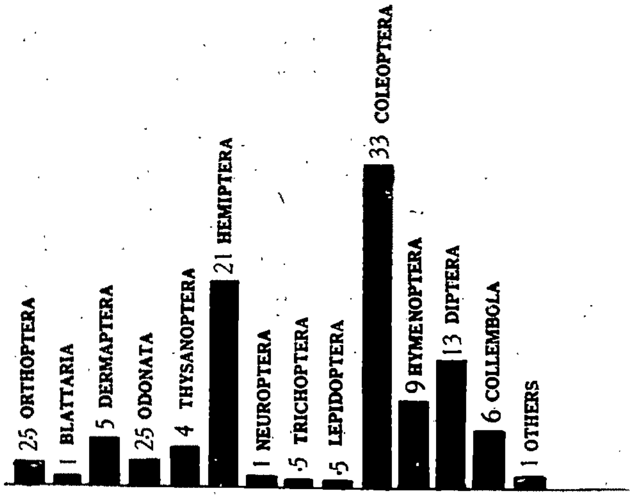


Fig. 7. The abundance of different Orders of insects between 6000 ft and 8000 ft, expressed as percentages of the total insects occurring beyond 6000 ft in the North-west Himalayas.

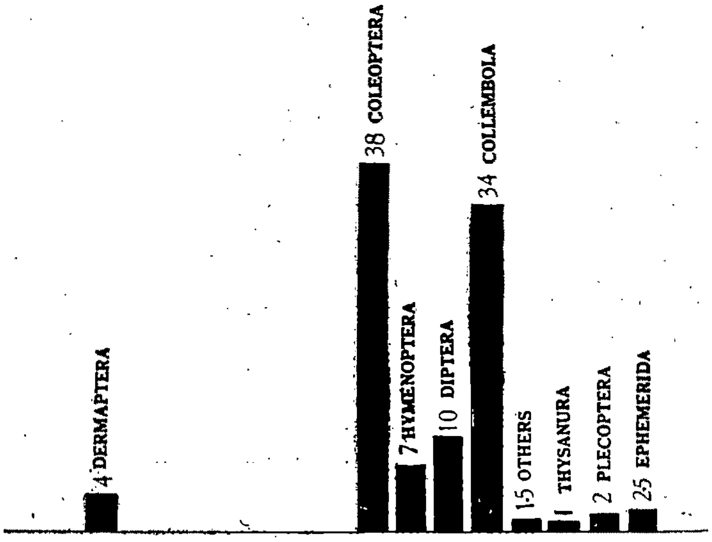


Fig. 8. The abundance of different Orders of insect between 8000 ft and 10,000 ft, expressed as percentages of the total insect occurring beyond 6000 ft in the North-west Himlayaas.

Hemipteroidea stands next to Coleoptera and represents about one-fourth the total insect population of the zone. Pentatomidae, Scutellaridae, Pyrrhocoridae, Lygaeidae, Tingidae, Coreidae, Gerridae, Nepidae, Miridae, Saldidae and Velidae are important Heteroptera. The Homoptera comprise Cicadidae, Jassidae, Coccidae and Aphididae and to a small extent Membracidae. The Cicadidae should perhaps be considered as the dominant Homoptera of the densely forested hills between 5000 ft. and 8000 ft.

Diptera, third in order of abundance, is represented by several species of Mycetophilidae, Bibionidae, Tipulidae, Chironomidae, some Itonididae and muscoid flies. Hymenoptera includes the parasitic families, ants and

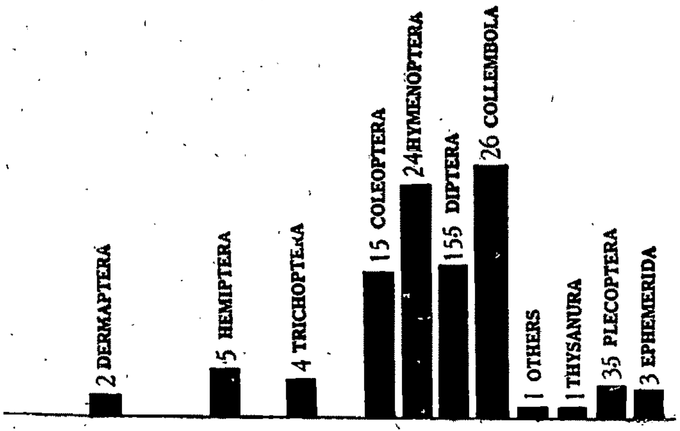


Fig. 9. The abundance of different Orders of insects between 10,000 ft. and 12,000 ft. expressed as percentages of the total insects, occurring beyond 6000 ft. in the North-west Himalayas.

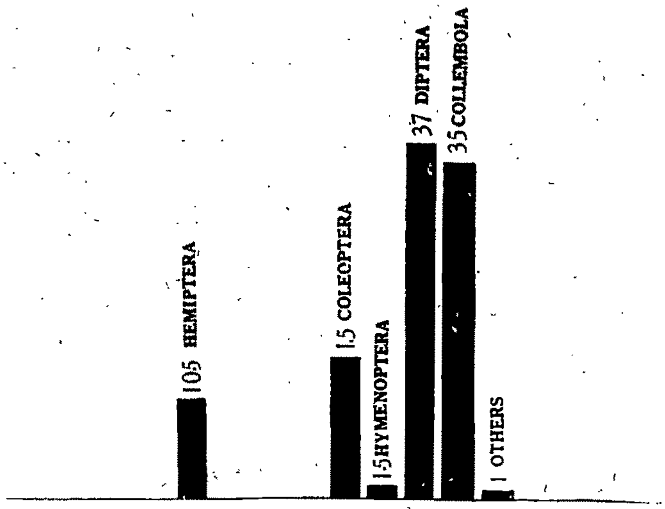


Fig. 10. The abundance of different Orders of insects between 12,000 ft. and 14,000 ft. expressed as percentages of the total insects, occurring beyond 6000 ft. in the North-west Himalayas.

solitary and social bees and wasps and some Cynipidae. Collembola constitutes hardly 6% of the total insect fauna of the zone and occurs generally under soil in ants' nests and near streams. Taken as a whole, the relative abundance of various Orders differs but little from the pattern characteristic of the tropical and subtropical faunal subdivisions of India.

In the next higher zone *i. e.* between 8000 ft. and 10,000 ft., it is interesting to observe the absence of predominantly stenothermal and stenohygric orders like Blattaria. Dermaptera does not show any significant change in abundance. The dominance of Coleoptera also persists. The second place is however taken up by Collembola, which now represents nearly 34% of the total, as compared with the hardly 6% below 8000 ft. Although there is no appreciable diminution in the numbers of Diptera, this Order stands next only in importance to Collembola. The dominance of Collembola over Diptera is really not the result of larger number of genera and species, but of individuals only. For the first time we observe a general reduction in the numbers of genera and species, but localised concentrations of individuals. The Coleoptera is largely represented by Carabidae, Staphylinidae, Tenebrionidae and Histeridae. A considerable proportion of Hymenoptera found in the zone belongs to species of the wood-boring wasps of the family Siricidae, which is generally absent at lower elevations.

The zone between 10,000 ft. and 12,000 ft. is largely a transitional one, mostly dominated by Collembola, Hymenoptera, Diptera and Coleoptera. The superior position of Collembola is once again due to individuals of a comparatively small number of species. Hymenoptera comprises mostly moderately large colonies of 3 or 4 species of ants and solitary pollen-gathering bees like *Bombus*, which have almost wholly replaced the social bees. In this zone the Adephaga gain considerable prominance. The total absence of Dytiscidae, Hydrophilidae and the general absence of surface-haunting species of aquatic Heteroptera are striking features of great significance. Plecoptera, Trichoptera and Ephemerida are somewhat more abundant than at lower elevations.

Between 12,000 ft. and 14,000 ft. the unmistakable patterns of the extreme altitude type of insect life are already apparent. The region is dominated by Collembola and Diptera. The pronounced increase in the numbers of Collembola and Diptera is very striking. Diptera is nearly twice as abundant here as between 10,000 ft. and 12,000 ft. Coleoptera now occupies a secondary place. Unlike Collembola, these two Orders however have greater variety. The Hemipteroidea met with in this zone is almost entirely blown up by upper air currents from lower elevations.

Beyond 14,000 ft. the permanent residents are Collembola, Diptera, Coleoptera, Plecoptera and Dermaptera. The Homoptera found here represents as before wind-blown specimens. A number of species of migrating Lepidoptera and some wind-blown moths are also frequently met with upto nearly 17,000 ft. Compared to the zone immediately below, there is a pronounced fall in the numbers of species and individuals of all groups.

The differences in the abundance of various Orders at different altitudes are shown in fig. 12. With the increase in altitude there is general fall in numbers of all types. Orders, families, genera and species become fewer, but the numbers of individuals of a comparatively few types reach up to about 20,000 ft. Some Orders disappear at comparatively low elevations, and others diminish more gradually. Three Orders viz. Collembola, Diptera and Coleoptera reach higher than all others. The relative abundance of these three predominantly high altitude groups in the 5 altitude zones is shown in figs. 13 and 14. Considered in relation to the total insect fauna, Collembola shows an abrupt increase in the second zone and this increase is maintained higher up. Coleoptera remains at a fairly high level in the first two altitude zones, but is halved higher. Diptera on the other hand abruptly gains superiority in the fourth altitude zone. There is however no intrinsic increase in numbers of Collembola. A reference to fig. 14 demonstrates the fall in abundance of all the three dominant high altitude Orders with increase in the altitude. Owing to the extreme conditions and the greatly exaggerated effects of microclimatic differences, in every case we find a relative of lack of variety. There are actually fewer genera and species at high altitudes. There is however a very pronounced localised concentration and over-crowding of a very large number of individuals of the relatively few species in microclimatic niches, offering optimum conditions.

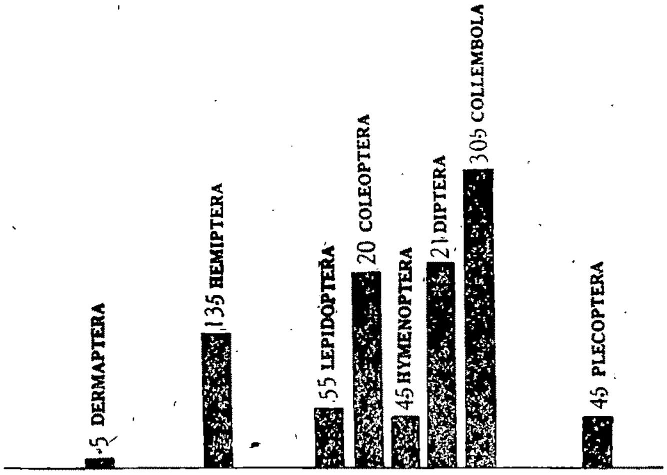


Fig. 11. The abundance of different Orders of insects above 14,000ft, expressed as percentages of the total insects occurring beyond 6000ft. in the North-west Himalayas.

The habits of the insects occurring at extreme altitudes, especially beyond the tree limits, are to a certain extent similar to those of the Central Asian and Tibetan species, and are in general determined not only by the conditions of altitude and aspect of the ranges but also by the more important local conditions. A considerable proportion of the species are active during daytime only on exposed rock, heated by the direct rays of the sun. Giant Thysanura like *Thermobia* sp. often gather in large masses on such rocky surfaces, during the day and feed on the dry lichen and other debris. Certain muscoid flies also come to the heated surface of the rock. Lizards have been often seen at about 14,000 ft. The insects occurring on barren and exposed rocks are capable of wide temperature

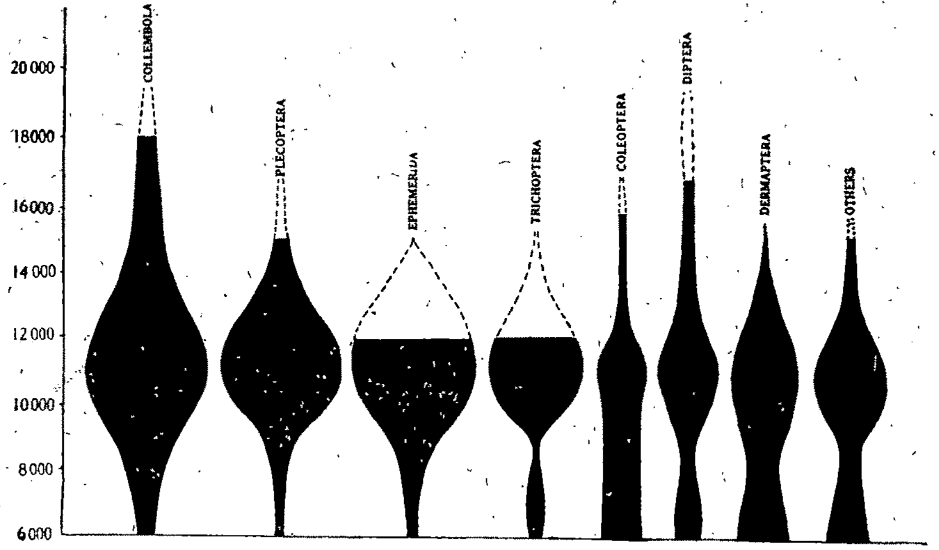


Fig. 12. The changes in the abundance of different Orders of insects with the increase in altitude from 6000ft. to 20,000ft.

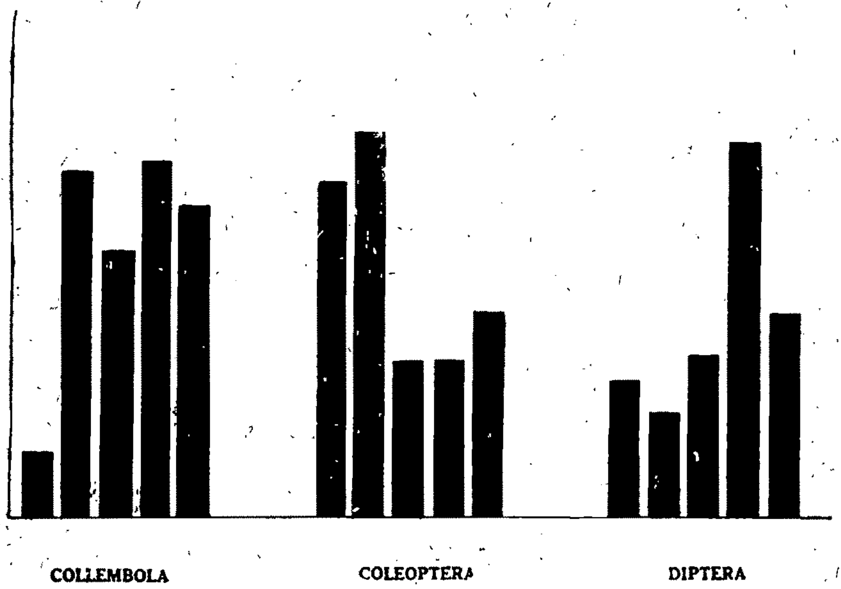


Fig. 13. The abundance of Collembola, Coleoptera and Diptera, expressed as percentages of the total insects in the altitude zones 1 to 5.

and humidity tolerance. The great majority of the forms found during the day on exposed rock are really transients from other habitats. They merely congregate on the heated rock surface to absorb the warmth and capture prey during the hours of sunshine.

The vast majority of flying insects like Ephemerida, Plecoptera, Trichoptera, Chironomidae, Tipulidae, Blepharoceratidae, Deuterophlebiidae, etc. are also active only in the sun. Syrphidae, Tachinidae, Sarcophagidae, Calliphoridae, *Bombus*, *Crabro* and other flower-visiting insects are also active in bright sunshine. Only a small proportion of species, especially certain Trichoptera and Plecoptera adults, some Diptera particularly Psychodidae, Simulidae and Chironomidae remain for the most part of the day in sheltered and shady parts. Dermaptera, Tenebrionidae and some Thysanura were found moving about on the rock surface only during the night. The Himalayan field mice should also be included in the category of forms active at night.

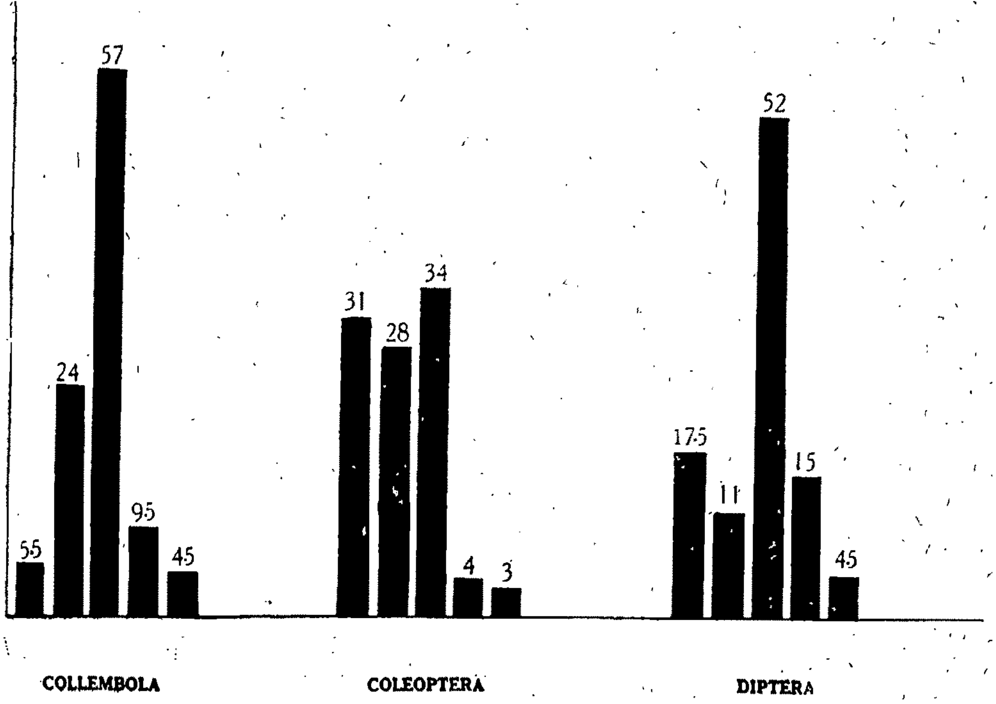


Fig. 14. The abundance of Collembola, Coleoptera and Diptera, expressed as percentages of the total of each Order in the altitude zones 1-5.

The great majority of the others like Carabidae, Staphylinidae, Dermaptera, many Collembola, mites both free-living and parasitic, centipedes and scorpions occur under fairly constant conditions of temperature, humidity, etc. under stones in underground shelters and are therefore nearly always active, quite irrespective of the external conditions. Most of the species that cannot survive the freezing under snow are usually found in easily accessible crevices in rock or in underground shelters offering fairly constant optimum conditions. Nearly all the insects of the glacial torrential streams have probably the most uniform conditions. Due to their fairly uniform conditions, there is a heavy concentration of both species and individuals in the torrents from 17,000 ft.

down to 10,000 ft. Nearly every submerged stone in any of the torrents offers identical conditions of optima, so that hundred of individuals are often anchored to them. Surface haunting aquatic forms, are extremely rare and are confined wholly to small localised sheltered parts of the torrents.

The preferred temperatures of most insects habitually occurring beyond the timber-line are considerably lower than in the case of the insects found at comparatively lower elevations, and appear to lie in most cases between 2°C and 10°C. The preferred temperature of the species that congregate on the exposed barren rock during the hours of sunshine are naturally however higher and would probably lie in the neighbourhood of about 22°C.

The tolerance of temperatures even slightly higher than those of the prevailing range in the particular microclimatic niche is exceedingly low in most species. The torrential insects, habitually living in water with only a temperature range of 2—4 degrees between 10,000 ft. and 17,000 ft, are adversely affected by even a slight increase in the temperature of the water exposed to the heat of the human body. The temperature optimum in nearly all the species is much lower than that for the insects of lower elevations. The threshold temperature for almost all the stages varies but little and is in neighbourhood of 5° C. The difference between the threshold and the optimum is thus not wide.

A pronounced heavy pigmentation of the body that characterises the majority of the species is most undoubtedly the result of the great intensity of sunlight, especially the ultra-violet part and the high glare due to reflection from the snow. Not only the species that come out in the open at some time or other, but also those that generally occur in sheltered places and are not ordinarily exposed, are heavily pigmented, spotted and otherwise marked. In such cases the development of heavy pigmentation seems to be connected with the effects of over-crowding of a great many individuals during the major part of their development, to which reference has already been made. Pale and colourless forms are as a rule absent. The prevailing lower temperatures would also probably account for a general darkening of the body colour. Colour spots and markings are generally larger than at lower elevations and often also tend to coalesce together into larger areas. The ground colour in most cases is of a deeper tone.

A striking feature of the insects occurring beyond the limits of tree-growth is the greatly prolonged larval period and the relatively short adult life. Even at relatively low elevations a large proportion of the species is characterised by short-lived imaginal stage. At extreme altitudes, the larval period is without exception, very much longer than the adult. The prolongation of the larval life is due in part to the slower rate of development, but largely to the arrest of development (diapause and hibernation) under snow-cover during autumn, winter and part of spring. Ephemerida, Plecoptera, Trichoptera and Diptera are familiar examples of the forms that remain as larvae for a whole year or even two years and emerge as adults on a sunny summer afternoon, mate, deposit their eggs and perish before the evening. Collembola and Coleoptera undergo hibernation both as larvae and as adults. The hibernation continues in most cases to the end of June or extends often into July also, even at 15,000 ft. The great

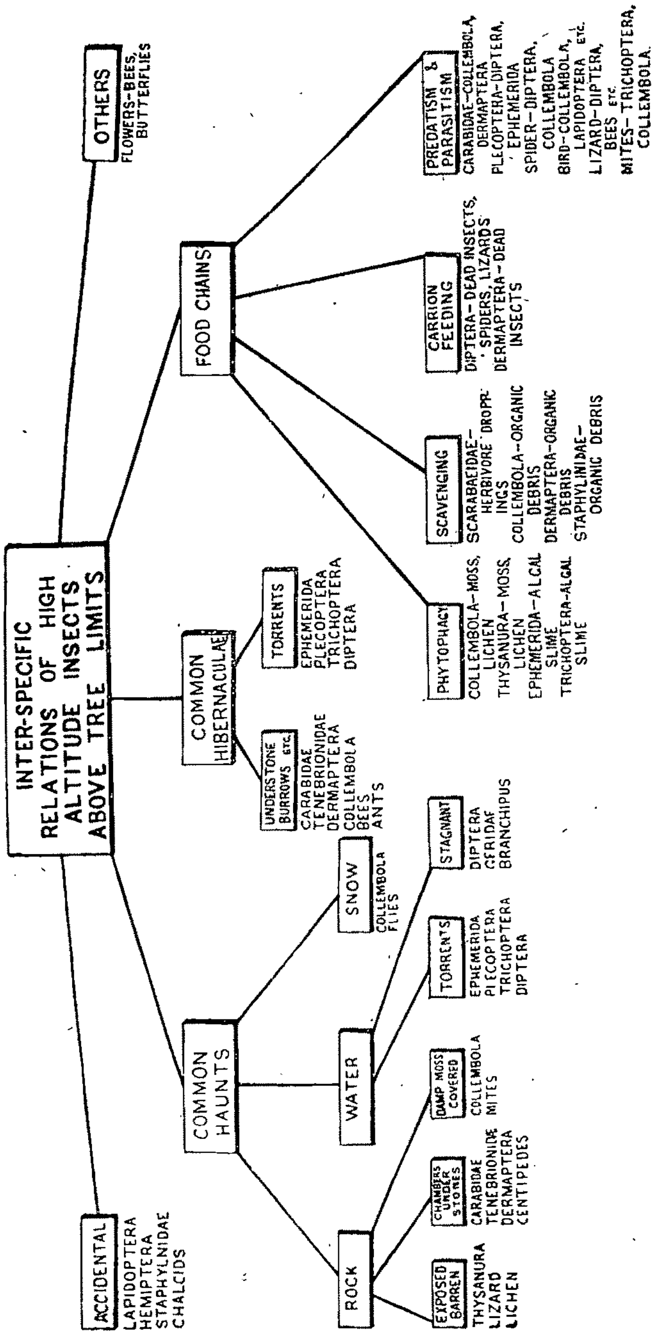

INTER-SPECIFIC RELATIONS OF HIGH ALTITUDE INSECTS ABOVE TREE LIMITS
OTHERS
FLOWERS-BEES, BUTTERFLIES
FOOD CHAINS
PREDATISM & PARASITISM
CARABIDAE-COLLEMBOLA, DERMAPTERA
PLECOPTERA-DIPTERA, EPHEMERIDA
SPIDER-DIPTERA, COLLEMBOLA
BIRD-COLLEMBOLA, LAPIDOPTERA ETC.
LIZARD-DIPTERA, BEES ETC.
MITES-TRICHOPTERA, COLLEMBOLA.
CARRION FEEDING
DIPTERA-DEAD INSECTS, SPIDERS, LIZARDS
DERMAPTERA-DEAD INSECTS
SCAVENGING
SCARABAEIDAE-HERBIVORE DROPPINGS
COLLEMBOLA-ORGANIC DEBRIS
DERMAPTERA-ORGANIC DEBRIS
STAPHYLINIDAE-ORGANIC DEBRIS
PHYTOPHAGY
COLLEMBOLA-MOSS, LICHEN
THYSANURA-MOSS, LICHEN
EPHEMERIDA-ALGAL SLIME
TRICHOPTERA-ALGAL SLIME
COMMON HIBERNACULAE
TORRENTS
EPHEMERIDA PLECOPTERA TRICHOPTERA DIPTERA
UNDERSTONE BURROWS ETC.
CARABIDAE TENEBRIONIDAE DERMAPTERA COLLEMBOLA BEES ANTS
COMMON HAUNTS
SNOW
COLLEMBOLA FLIES
WATER
STAGNANT
DIPTERA GERIDAE BRANCHIPUS
TORRENTS
EPHEMERIDA PLECOPTERA TRICHOPTERA DIPTERA
ROCK
DAMP MOSS COVERED
COLLEMBOLA MITES
CHAMBERS UNDER STONES
CARABIDAE TENEBRIONIDAE DERMAPTERA CENTIPEDES
EXPOSED BARREN
THYSANURA LIZARD LICHEN
ACCIDENTAL
LAPIDOPTERA HEMIPTERA STAPHYLINIDAE CHALCIDS

Fig. 15. Simplified diagrammatic representation of the more important interspecific relations of the high altitude insects and other organisms, beyond the limits of tree-growth in the North-west Himalayas.

bulk of the specimens of Carabidae, Tenebrionidae and Dermaptera collected by the Expedition were really found hibernating as late as end of June about 13,000 ft. As far as we were able to observe there is but a single generation in the year in all cases.

The food habits of the insects of the extreme altitudes present a number of extremely interesting peculiarities. Only a relatively small number of species are truly phytophagous and depend on the algal slime in the torrents, lichen and moss on the rocky surface, grass and other dwarf vegetation. A few species thrive on the pollen grains of a variety of plants like the dwarf juniper blown up on rock and snow fields by air currents from the lower elevations and from the plains. Certain species apparently feed on fungi. Several species are however scavengers and depend on a variety of organic debris found in rock crevices, ants' nests, below the low vegetation and other similar situations. The vast majority of the insects occurring in this region are however either carrion feeders or are active predators that, devour all sorts of smaller insects and often also each other. While truly phytophagous species are on the whole restricted to the relatively lower levels and also constitute a small proportion of the total insect population near about 14,000 ft., carrion-feeding and predatory species occur increasingly as we ascend higher and higher. Indeed they are the only ones which exist in the neighbourhood of elevations of 17,000 ft. and above.

The complex inter-relationships of the high altitude insects are largely determined by altitude and local conditions. Some of the more important interspecific relations observed by us in the field are represented as a simplified diagram in fig. 15. An endless and extremely complex food-chain, shown separately in pl. xxviii, connects directly or indirectly the insects with nearly every other organism like lichen, moss, rodents, lizards, migratory birds, yak, Himalayan bears, etc. Beginning with the pioneers lichen and moss that invade the barren rocks and pave the way for other types of organisms, we observe the linking up of various insects through Collembola, which constitute the chief food supply for an amazing variety of insects, birds and other animals. While several insects feed on dead and living Collembola, the latter in turn feed on the dead bodies of their predators. Not a single species is really independent but its life is closely bound up with the lives of every other species in some way or other. The urge for seeking optimum conditions brings together a great array of species, linking their lives more or less closely. Common hibernaculae provide the basis for association of many types. The different types of the inter-relations are not however equally important throughout the zone between 10,000 ft. and 17,000 above. While food-chain associations continue to operate even at these extreme elevations, it ranks only second to the associations in common shelters (Fig. 16). All the other relationships gradually lose their importance as we go higher and higher. Owing to the primary need for seeking common micro-climatic niches of optimal conditions, insects with widely different habits and food preferences, often come to be associated together. The occurrence, for example, of two species of insects or other Arthropods and insect in a rock crevice or under a stone or other similar shelter at an elevation of 18,000 ft. is the result not primarily of operation of the food-chain but arises from the species having found only here those optimal conditions favourable to them in an otherwise extensive area of adverse conditions. We thus often observe flies and spiders inhabiting the same shelter for a greater part of the time at these altitudes. Carabidae and Dermaptera similarly occur under the same stones because both are attracted to the place by the favourable micro-climate that exists. It looks as if because of the extremely adverse conditions common to all the species, a sort of 'temporary truce' has been declared and different species, normally not found together, remain 'in peace' in the only place where they can at all survive. Solitary habits are, as a rule rare. The prevailing adverse conditions encourage gregariousness, mass assemblages and over-crowding not merely of the individuals of a single species, but of widely unrelated orders, genera and species, with very divergent habits. Mircro-climatic conditions provide the clue to this characteristic of high altitude insect life.

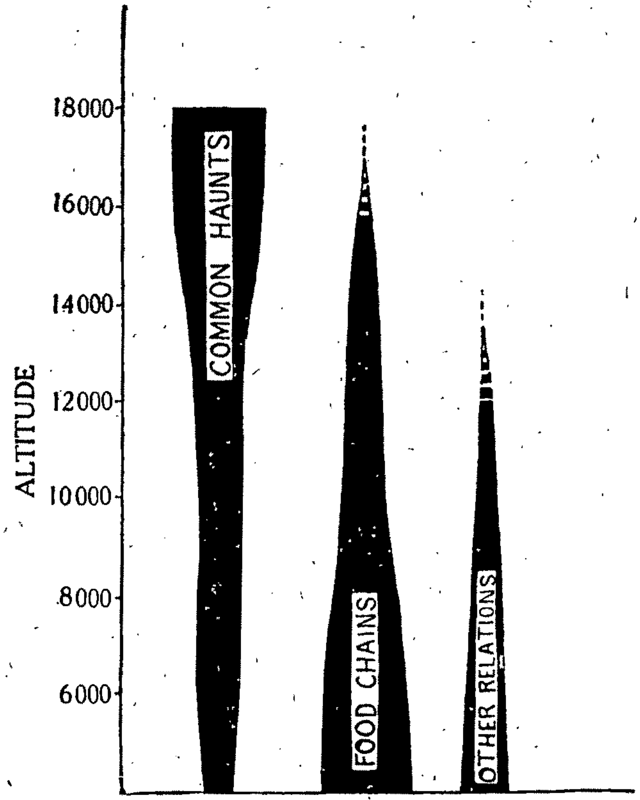


Fig. 16. The changes in the importance of the different types of inter-relationships with the increase in altitude in the North-west Himalayas.

The ecological and genetic isolation of the high altitude insect life beyond the tree limits should not by any means be interpreted in terms of the independence of the insects living here. Just as the high altitude insects are bound up with the lives of the high altiude plants and other animals, both directly and indirectly in a complex variety of ways, the high altitude life as a whole is linked up with life in the plains in an equally complex manner (fig. 17). To take only the most obvious connection observed by us, the upper air currents transport from the plains and from the lower elevations, enormous masses of fungal spores, pollen grains of a great variety of plants, inorganic and organic debris (dusts), countless millions of smaller insects like aphids, jassids, flies, gnats, midges and often relatively larger species like noctuid moths over vast stretches of the country and ultimately blow them on high altitude regions on snow fields and rocks, between 13,000 ft. and 20,000 ft., especially on the southern aspects of the ranges. We found, for example, on snow fields at about 14,000 ft. and 16,000 ft., both on the slopes and summits, vast swarms of frozen aphids, jassids, fruitflies and noctuid moths, familiar to us as important pests of farm and orchard in Kulu and Kangra valleys, Punjab. Hordes of Carabidae, Staphylinidae, Dermaptera, Brachycerous Diptera and Collembola visit these snow fields to devour the frozen meat supply literally air-lifted from the plains. Migrating swarms of butterflies substantially add to this stock of food for the high altitude insects. One of us witnessed the total annihilation of a gigantic swarm of migrating butterflies, *Colias ladakensis* and *Argynnis clavdia*, in a violent snow storm at about 16,000 ft., at the end of which the snow-field was littered with thousands of dead butterflies. An important source of the food supply of the extreme altitudes is thus derived actually from the lower elevations and plains. Collembola, on which

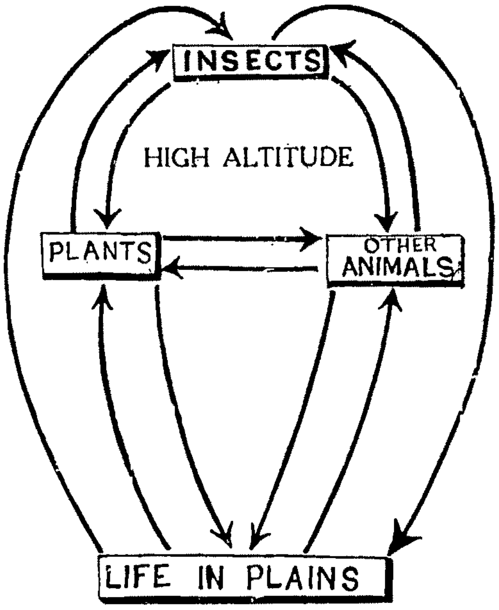
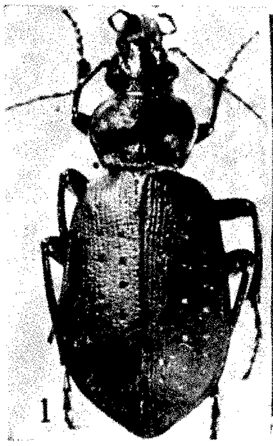


Fig. 17. Simplified diagram of the inter-relationships of organisms in the high altitude and in the plains.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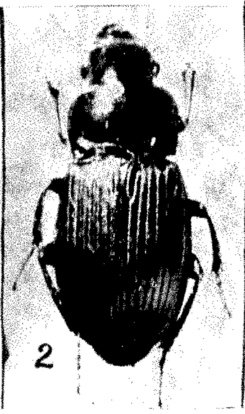
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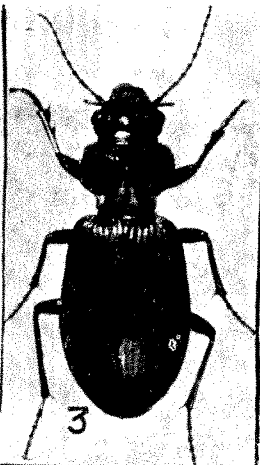
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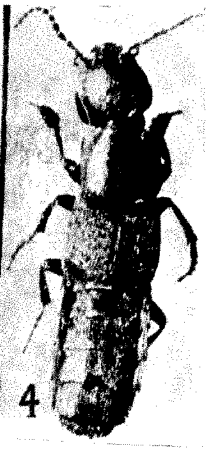
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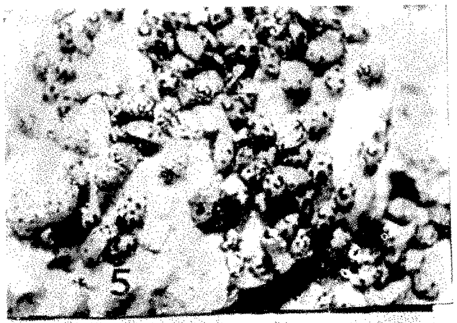
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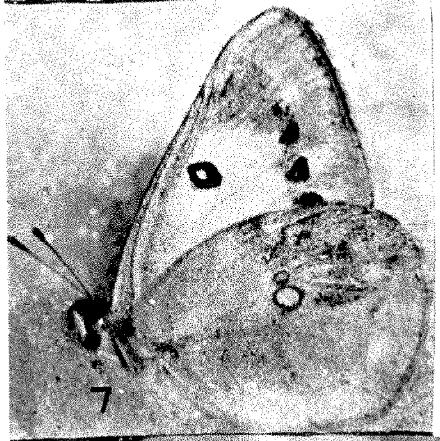
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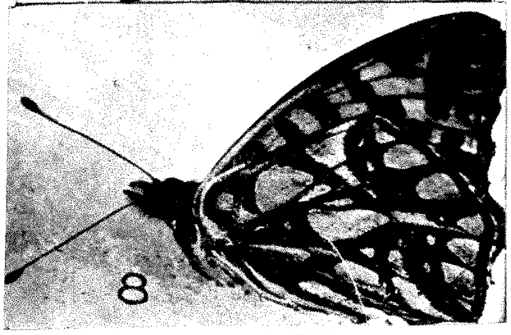
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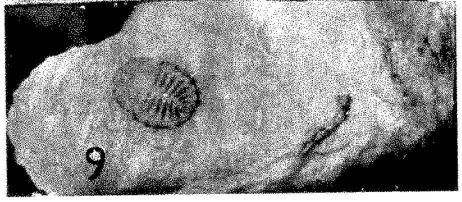
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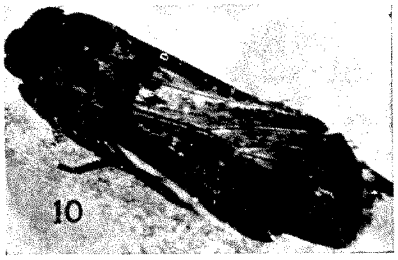
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M. S. MANI & SANTOKH SINGH

PLATE XXVII

M. S. Mani & Santokh Singh: Entomological Survey of the Himalayas

SOME OF THE MORE COMMON HIGH ALTITUDE INSECTS

1. *Calosoma madeirae kashmirense* hibernating at about 14,000 ft. under stones covered by snow.

2. & 3. Two other Carabid beetles from between 13,000 ft. and 15,000 ft., also taken hibernating.

4. Staphylinid beetle occurring at the edges of snow fields at about 14,000 ft.

5. Hibernating mass asemblage of Coccinellid beetle on a glacier at about 14,000 ft. on Dhauladhar (near Lakka Pass), found in an earlier visit.

6. *Anechura himalayana* Santokh running in search of food at about 14,000 ft.

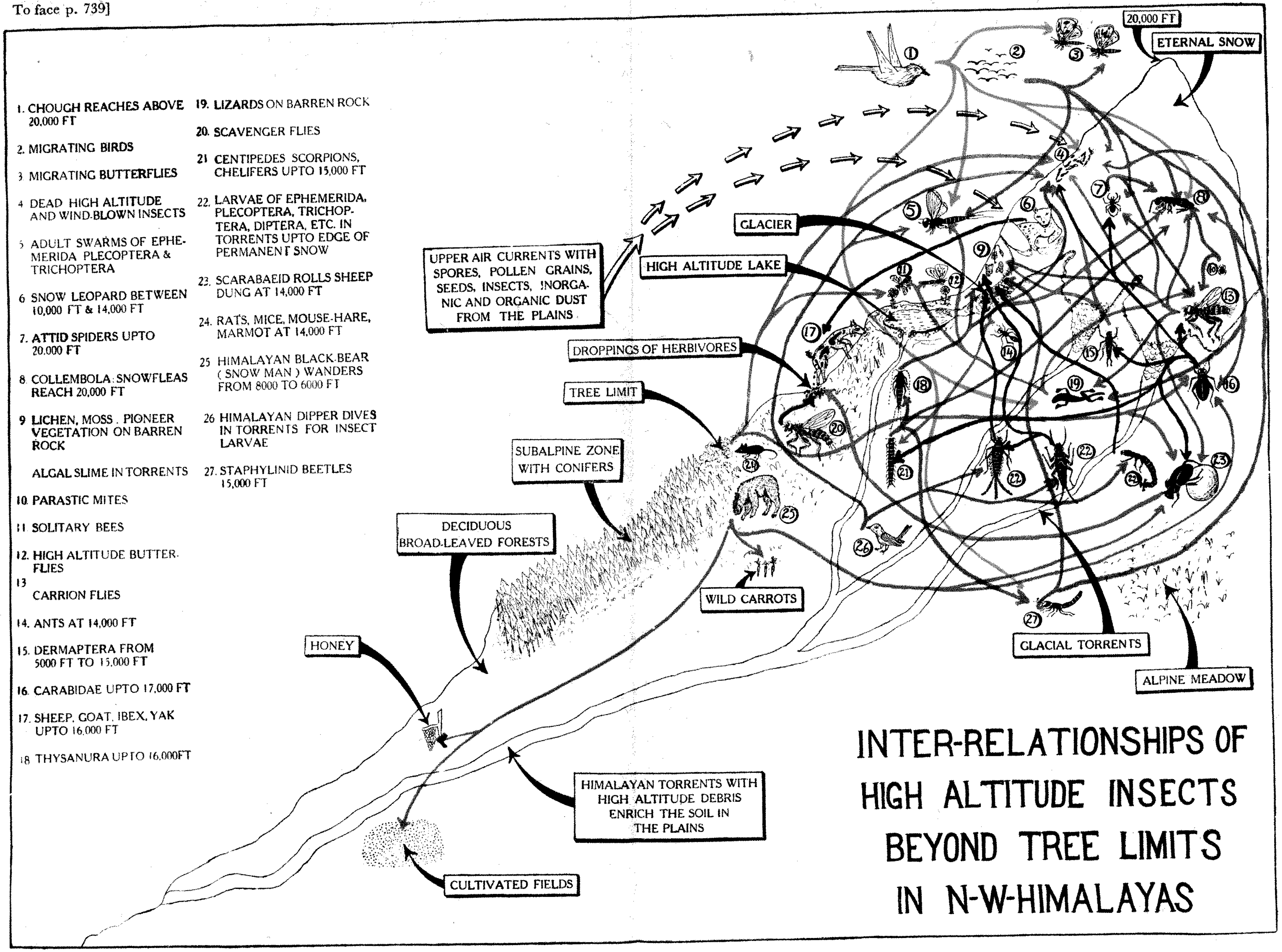
7. *Colias ladakensis* occurring between 16,000 and 17,000 ft.

8. *Argynnis claudia* settled on a snow field below 17,000 ft.

9. A torrential beetle larva (Dryopidae) anchored to a submerged stone at comparatively low elevations of about 8000 ft., especially in the outer ranges.

10. Dead and frozen Noctuid moths cast by upper air currents on glaciers near 14,000 ft.

(All photographs are black and white copies of Kodachrome transparencies made in the field by Prof. M. S. Mani.)



INTER-RELATIONSHIPS OF HIGH ALTITUDE INSECTS BEYOND TREE LIMITS IN N-W-HIMALAYAS

1. CHOUGH REACHES ABOVE 20,000 FT
2. MIGRATING BIRDS
3. MIGRATING BUTTERFLIES
4. DEAD HIGH ALTITUDE AND WIND-BLOWN INSECTS
5. ADULT SWARMS OF EPHEMERIDA PLECOPTERA & TRICHOPTERA
6. SNOW LEOPARD BETWEEN 10,000 FT & 14,000 FT
7. ATTID SPIDERS UPTO 20,000 FT
8. COLLEMBOLA: SNOWFLEAS REACH 20,000 FT
9. LICHEN, MOSS. PIONEER VEGETATION ON BARREN ROCK

ALGAL SLIME IN TORRENTS

10. PARASTIC MITES
11. SOLITARY BEES
12. HIGH ALTITUDE BUTTERFLIES
13. CARRION FLIES
14. ANTS AT 14,000 FT
15. DERMAPTERA FROM 5000 FT TO 15,000 FT
16. CARABIDAE UPTO 17,000 FT
17. SHEEP, GOAT, IBEX, YAK UPTO 16,000 FT
18. THYSANURA UPTO 16,000FT
19. LIZARDS ON BARREN ROCK
20. SCAVENGER FLIES
21. CENTIPEDES SCORPIONS, CHELIFERS UPTO 15,000 FT
22. LARVAE OF EPHEMERIDA, PLECOPTERA, TRICHOPTERA, DIPTERA, ETC. IN TORRENTS UPTO EDGE OF PERMANENT SNOW
23. SCARABAEID ROLLS SHEEP DUNG AT 14,000 FT
24. RATS, MICE, MOUSE-HARE, MARMOT AT 14,000 FT
25. HIMALAYAN BLACK-BEAR (SNOW MAN) WANDERS FROM 8000 TO 6000 FT
26. HIMALAYAN DIPPER DIVES IN TORRENTS FOR INSECT LARVAE
27. STAPHYLINID BEETLES 15,000 FT

20,000 FT
ETERNAL SNOW
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GLACIER
HIGH ALTITUDE LAKE
UPPER AIR CURRENTS WITH SPORES, POLLEN GRAINS, SEEDS, INSECTS, INORGANIC AND ORGANIC DUST FROM THE PLAINS
DROPPINGS OF HERBIVORES
TREE LIMIT
SUBALPINE ZONE WITH CONIFERS
DECIDUOUS BROAD-LEAVED FORESTS
WILD CARROTS
HONEY
GLACIAL TORRENTS
ALPINE MEADOW
HIMALAYAN TORRENTS WITH HIGH ALTITUDE DEBRIS ENRICH THE SOIL IN THE PLAINS
CULTIVATED FIELDS

M. S. MANI & SANTOKH SINGH

PLATE XXVIII

M. S. MANI & SANTOKH SINGH

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS

A simplified diagram of the inter-relationships, chiefly food-chains, of the high altitude insects beyond the limits of tree-growth in the North-west Himalayas. The coloured lines connecting different organisms indicate the more obvious food-chain interdependence observed. In depicting these inter-relationships between 10,000 ft. and 20.000 ft. a precise altitudinal location of the organisms concerned is avoided with a view to simplicity of the diagram.

Lichen, fungi, moss and other dwarf plants occurring above the tree-line provide the food for a great variety of insects like Collembola, which also depends to a large extent on wind-blown pollen grains. The lives of a great many insects and other animals, chiefly carrion feeders and predators, are bound up directly or indirectly with Collembola. The high altitude chough depends on migrating butterflies, adult flying insects like mayflies, stoneflies, caddisflies, Collembola, wind-blown insects and often also lizards.

The interdependence of the high altitude insects with the life in the plains is also shown in part. A great variety of inorganic and organic particles like pollen grains, spores, millions of smaller insects and often also larger forms like noctuid moths, transported by upper air currents from the plains and lower elevations and deposited on rock and snow fields above 13,000 ft. constitute an important source of food supply for the high altitude insects.

The examples shown do not by any means exhaust those actually observed in the field; a great many instances are omitted for the sake of simplicity.

the lives of many other high altitude insects directly depend, is in its turn dependent on the wind-blown pollen, in addition to the lichen and moss. Glacial action and erosion carry down the soil and humus formed by lichen and all other debris of high altitude animal and plants to enrich the plains.

In the invasion and colonisation of the high altitudes in the Himalayas, lichen and moss have unquestionably been the pioneers. The insects have followed them closely behind and have in turn created the necessary favourable conditions for others. The success which the insects have had at extreme altitudes is undoubtedly due to their having taken advantage of the microclimatic niches and adaptation for variety of habitats and in this their body size and general organization have largely helped them.

VI. SUMMARY

The general conditions of life beyond the limits of tree growth in the North-west Himalayas are extreme. Small microclimatic differences are greatly exaggerated and a wide range of micro-climatic niches, offering uniform optimal conditions for a variety of insects, are found throughout the region, quite irrespective of the altitude and atmospheric conditions. With the increase in altitude there is a general fall in the numbers of groups, but we find localised concentrations of large numbers of individuals of a relatively few forms in small pockets of micro-climatic optima. Collembola and Diptera occur at much higher elevations than other insects. With the increase in altitude there is also an increase in the proportion of carrion-feeding and predatory forms, until at extreme elevations they are the only ones that exist. A complex chain of food and other interrelationships connects the high altitude life with life at lower elevations. The insects occurring in the region are related to the Tibetan and Central Asian faunal elements.

VII. ACKNOWLEDGMENTS

We take this opportunity of expressing our cordial thanks to the authorities of the St. Johns' College for encouragement and help. We are indebted to the Agra University for the generous grant of a small financial assistance. Our sincere thanks are also due to the Director, Zoological Survey of India for the interest shown and to the Punjab Government for providing the necessary facilities. We are specially grateful to Sardar Niranjan Singh, the Divisional Forest Officer, Kulu, to whom the success of the Second Expedition is entirely due. Lastly we must also thank the members of the Expedition for their willing co-operation and very hard work under extremely adverse conditions in the high altitudes.

ENTOMOLOGICAL SURVEY OF THE HIMALAYAS*

PART XIV.—NOTES ON SOME INSECTS COLLECTED BY THE SECOND ENTOMOLOGICAL EXPEDITION TO THE NORTH-WEST HIMALAYAS (1955), WITH DESCRIPTION OF THREE NEW SPECIES OF ODONATA

By SANTOKH SINGH, M. SC., H. N. BAIJAL, M. SC., F. R. E. S., V. K. GUPTA, M. SC., F. R. E. S. and KOSHY MATHEW, M. SC., *Research Associates, School of Entomology, St. John's College, Agra.*

This paper is a report on a small part of the collections of insects brought back from the high altitudes, especially beyond the timber-line in Lahoul-Spiti by the Prof. Mani School of Entomology Second Entomological Expedition to the North-west Himalayas (1955). Of the 58 species reported here, 4 comprise Dermaptera, 11 (of which 3 are new) Odonata, 15 Heteroptera, 16 Hymenoptera, 6 Lepidoptera and 3 Collembola. Some of the species are being recorded here for the first time from this part of the Himalayas. The altitude record for Dermaptera is the highest so far in the world. The Odonata and Heteroptera come mostly from relatively low elevations. The Lepidoptera include truly high altitude species and migratory forms. A few species collected on earlier occasions are also included. The specimens will ultimately be deposited in the National Collections of the Zoological Survey of India. The descriptions of the Stations are given at the end. Our grateful thanks are due to Prof. Dr. M. S. Mani, for facilities for work and for guidance.

Section A. By Santokh Singh

Order DERMAPTERA

Family FORFICULIDAE

Subfamily Anechurinae

Anechura himalayana Santokh Singh

1955. *Anechura himalayana*, SANTOKH SINGH, *Agra Univ. J. Res.* (*Sci*), **4** (1) : 180
1955. *Himenechura lahaulensis*, SANTOKH SINGH, *Agra Univ. J. Res.* (*Sci*), **4** (1): 184 (New Syn.).

10 males 9 females, Coll. Nos. 10.1/55-10. 16/55 and 8.3/55-8.5/55. Prof. M. S. Mani School of Entomology Expedition to Himalayas; Rahla, 8835 ft., Coll. Santokh Singh, 25.vi. 1955." Sta. Nos. 7 & 8; Cardex No. 12 & 19.

Tubercles at the base of the forceps are on the inner margin rather than on the upper side as in the type specimen. The last four segments of the abdomen coloured dirty orange.

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*Contribution No. 67 from the School of Entomology, published with the permission of the Professor of Zoology & Entomology.

Originally described from Upper Chenab Valley (Lahaul Valley 10,000 ft. to 12,090 ft.

This is the first record from the Upper Beas Valley.

With the additional material now available the earlier described form is recognised as representing the immature stages of this species.

Anechura bipunctata pirpanjalae Santokh Singh

1955. *Anechura bipunctata pirpanjalae,* SANTOKH SINGH, *Agra Univ. J. Res.* (Sci.), **4** (1) : 182.

2 males 2 females, Coll. Nos. 136. 5/55, 136. 6/55, 137. 7/55; 137. 8/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Marhi, 12,000 ft. Coll. V. K. Gupta, 31. v. 1955 & 1. vi. 1955." Sta. No. 18, Cardex No. 34 & 37.

1 male & 1 female, Coll. No. 155/55; Coll. V. K. Gupta and H. N. Baijal, 7. vi. 1955, Cardex No. 54.

2 males & 1 female, Coll. No. 180/55; Coll. V. K. Gupta. 8 vi. 1955. Cardex No. 62.

1 male Coll. No. 257/55; Coll. H. N. Baijal, 7 vi. 1955. Cardex No. 46.

2 males & 1 female, Coll. No. 258/55; Coll. H. N. Baijal, 8 vi. 1955. Cardex No. 47.

1 male Coll. No. 306/55; Col. V. K. Gupta, 11 vi. 1955. Cardex No. 75.

"Prof. M. S. Mani School of Entomology Expedition to Himalayas Gramphu, 12,000 ft." Sta. Nos. 24 & 26.

1 male & 1 female Coll. Nos. 82. 6/55, 82. 7/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Opp. Kulti Nal, 12,000 ft., Coll. Santokh Singh, 10. vi. 1955." Sta. No. 26, Cardex No. 73.

18 males & 2 females Coll. Nos. 77. 36/55-77. 38/55, 76/55, 182/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Kulti Nal, 11,600 ft. Chandra Valley, Coll. Santokh Singh, 9 vi 1955." Sta. 28 & 29, Cardex No. 67 & 68.

1 male 2 females Coll. No. 86/55, 312. 13/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Dhorni, 12,000 ft. Coll. Santokh Singh and V. K. Gupta, 13. vi. 1955." Sta. 31, Cardex No. 77 & 78.

4 males and 6 females Coll. No. 90/55, 314. 23/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Chhatru, 12,000 ft. Chandra Valley; Coll. Santokh Singh and V. K. Gupta, 15. vi. 1955." Sta. 35, Cardex No. 81 & 83.

1 male Coll. No. 531/55. "Prof. M. S. Mani School of Entomology to Himalayas; Hamta Jot, 14,500 ft. Coll. Santokh Singh, 16. vi. 1955." Sta. 37 and Cardex No. 89.

Previously recorded from Northern aspects of the Pir Panjal Range and the present collection contains specimens from the Southern aspect also.

Subfamily Forficulinae

Forficicula beelzebub Burr

1910. *Forficula beelzebub,* BURR, *Fauna Brit. India* (*Dermap.*); 167; fig. 56.

5 males and 8 females Coll. No. 361. 2/55-361. 4/55, 579. 6/55, 579. 8/55-579. 14/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Manali, 6,500 ft., Coll. Santokh Singh, 25. vi. 1955." Station near 5 and 2, Cardex No. 115 and 117.

Previously recorded from Nepal : Chitlong, Kathmandu, Nagarkote; Sikkim : Darjeeling; Assa : Kurseong.

This is the first record of this species from the N. W. Himalayas.

Family LABIDURIDAE

Subfamily LABIDURINAE

Labidura riparia icterica Serv.

1773 *Forficula riparia,* PALLAS, Reis durch verschiedened Provinzen des Russischen Reiches in den Jahren, 1768-74. St. Petersberg. 2 te Anhang. p. 50.
1839. *Foricesila icterica,* SERVILLE; *Hist. Nat. Ins. Orth.,* Paris, p. 25.
1863. *Labidura riparia,* DOHRN, *Stett. ent. Z.,* 24 : 313.
1910. *Labidura riparia icterica,* BURR, *Fauna Brit. India,* (*Dermap.*), 99—102.

5 females Coll. Nos. 579. 1/55-579. 5/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Manali, 6,500 ft., Coll. Santokh Singh, 25. vi. 1955." Station near No. 5, and Cardex No. 117.

Previously recorded from India, Ceylon and China. The present collection extends its range into the N. W. Himalayas.

Section B. By H. N. Baijal

Order ODONATA

Suborder *ANISOPTERA*

Family CORDULEGASTERIDAE

Cordulegaster brevistgima brevistigma (Selys).

1854. *Thecogaster brevistigma,* SELYS, *Bull. Acad. Belg,* (2) **21** : 103.
1923. *Cordulegaster brevistigma,* FRASER *J. Bombay nat. Hist Soc.* **29** : 40-42, fig. 5.
1936. *Cordulegaster brevistigma brevistigma,* FRASER, *Fauna Brit. India,* Odonata **3** : 32-35, fig. 9.

1 Male, Coll. No. 103/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Manali, Coll. V. K. Gupta, 23-v-1955." Sta. No. 1; Cardex No. 5.

The specimen before me differs from the typical form in the following respects : Wing hyaline, without pale greenish tinge basally and along costa; 2 cubital nervures in both fore and hind wings; anal loop with 7 cells; abdominal segment 9 without a small baso-lateral angulated spot; segment 10 without a narrow basal ring.

The species has been previously recorded from the Himalayas and is distributed from Kashmir to Assam.

Family LIBELLULIDAE

Nanophya katrainensis, sp. nov. of H. N. Baijal

Female.—Abdomen 15 mm. Hind wing 24 mm. Labium and labrum light brown, rest of face and frons including vesicle brown; occiput black. *Prothorax* brown and small. *Pterothorax* brown, with all sutures finely black. *Legs* brown, marked with black. *Wings* hyaline; pterostigma light yellow, covering about one and a half cell; nodal index $\frac{8-8}{7-6}\Big/\frac{5-7}{6-6}$; only 1 cubital nervure in both wings; discoidal cell of fore wing strongly angulated at about middle of costal border. *Abdomen* reddish-brown, marked with black as follows : all the jugal suture black; middorsum marked with black; segments 6, 7 marked with black dorso-laterally and segments 8, 9 & 10 marked except in the middle, where there is a reddish-brown dot. *Anal appendages* brown.

Holotype 1 female. Coll. No. 341/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas" Katrain (Kulu) 5500 ft. Coll. V. K. Gupta, 24-vi-1955. Sta. No. 42. Cardex No. 112. In a paper envelope.

This species is very similar to *Nanophya pygmaea** Rambur from the Lower Burma, Siam, Borneo, Celebes and Sumatra, Malaysia and Indo-China, but differs in the colour, nodal index, absence of basal marking on wing and the abdominal segments 2-6 lacking pale yellow spots.

Orthetrum pruinosum neglectum (Rambur).

1842. *Libellula neglecta,* RAMBUR, *Ins. Neurop.,* 86.
1936. *Orthetrum pruinosum neglectum* FRASER, *Fauna Brit. India,* Odonata, **3** : 311-313.
1955. *Orthetrum pruinosum neglectum,* BAIJAL & AGARWAL, *Agra Univ. J. Res.* (Sci.) **4** (1) : 456.

1 Male, Coll. No. 411/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Kulu-Mandi Road, 3500 ft." Coll M. S. Mani, June 1955. Sta. No. 4, Cardex No. 107.

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*FRASER, F. C. 1936. Fauna Brit. India, Odonata, 3 : 322-323.

The specimen agrees very well with the description of the species. The species has been recorded previously from the whole of India, Ceylon and Burma and extends into Tibet, Indo-China and Hongkong. It is one of the commonest species in the plains and occasionally in Ootacamund in the Nilgiris at about 7250 ft. above sea level.

Recently it was recorded from the Gwalior State also.

Orthetrum cancellatum cancellatum (Linn).

1758. *Libellula cancellata*, LINNAEUS, *Syst. Nat.*, (10) **1** : 544.
1936. *Orthetrum cancellatum cancellatum*, FRASSER, *Fauna Brit. India*, Odonata, **3** : 302-304.
1955. *Orthetrum cencellatum cancellatum*, BAIJAL & AGARWAL, *Agra Univ. J. Res.* (Sci.) 4 (1) : 457.

4 Males, Coll. No. 339/55 & 341/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain Kulu Road, 5500 ft." Coll. V. K. Gupta, 24-vi-1955. Sta. No. 42, Cardex No. 112.

A Palaearctic species that extends from the British Isles across Europe and North Africa to Asia Minor and Kashmir. It was recently found in the plains of India.

Orthetrum Japonicum internum MacLachlan

1894. *Orthetrum japonicum internum.* MACLACHLAN, *Ann. Mag. Nat. Hist*, (6) **13** : 431.
1918. *Orthetrum japonicum internum*, FRASER, J. *Bombay Nat. Hist. Soc.*, **26** : 156-158.
1936. *Orthetrum japonicum internum*, FRASER, *Fauna Brit. India*, Odonata, **3** : 304.

1 Female, Coll. No. 339/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain (Kulu) 5500 ft. Coll. V. K. Gupta, 24-vi-1955. Sta. No. 42, Cardex No. 112.

The specimen differs from the description of the species in the following respects : Wing without amber-yellow tinting at base; pterostigma covering about two and a half cells; anal appendages not black; and lacking large bright citron-yellow spot on trochanters.

The species has been previously recorded from Kashmir, Nepal, Eastern Himalayas, Tibet, South-West China and Assam.

Orthetrum chrysostigma luzonicum (Brauer)

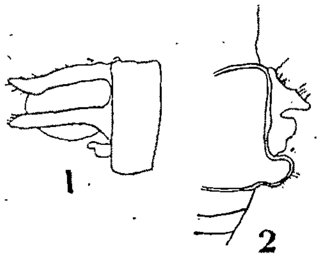
1868. *Libellula luzonica*, BRAUER, *Verh. zool. bot. Ges. Wien*, **18** : 169, 732.
1936. *Orthetrum chrysostigma luzonicum*, FRASER, *Fauna Brit. India*, Odonata, **3** : 298-300.

3 Males . Coll. No. 339/55, 341/55, 548/55; 2 females Coll. No. 548/55, 340/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas" Katrain (Kulu), 5500; Manali 6500 ft. Coll. V. K. Gupta, 23-24 vi. 1955. Sta. No. 42 & 3. Cardex No. 110 & 112.

This species occurs throughout India and Ceylon, but only in the submontane and montane regions of south. It is also known from Philippines, South Asia, Java and Sumatra.

Orthetrum guptai, sp. nov. of H. N. Baijal

Male.—Abdomen 27 mm. Hind wing 35 mm. Labium and labrum brownish black; face and frons olivaceous; vesicle and occiput black. *Prothorax* greenish-yellow. *Pterothorax* olivaceous green covered with stiff setae; mid-dorsal carinal suture marked black; antehumeral region greyish-green; humeral suture black; mesepimeron apple-green; anterolateral suture blackish-olivaceous; posteriolateral suture black; metepimeron apple-green. *Legs* black with femora of front legs yellowish. *Wings* hyaline, pterostigma brown covering about one and a half cell, discoidal cell of fore wing and hind wing traversed once; 2 rows of cells between IRiii and Rspl; Cuii at the posterior angle of discoidal cell in hind wing; *Abdomen* broad at base, tapering to the anal end, triquetral in cross section; black with a broad greenish-yellow stripe on mid-dorsum extending from segment 1-9 and segment 10 entirely black. *Anal* appendages (fig. 1) black of the usual libelluline shape. *Genitalia* as in fig. 2.



Orthetrum guptai sp. nov. of H. N. Baijal Fig. 1. Anal appendages Fig. 2. Genitalia.

Holotype 1 male, Coll. No. 10.3/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Manali, 65000 ft. Coll. V. K. Gupta, 23-v-1955. Sta. No. 1, Cardex 5. In a paper envelope.

This species resembles *Orthetrum garhwalicum* Santokh & Baijal, from which it can readily be distinguished by its characteristic colour of pterothorax and genitalia.

Sympetrum commixtum (Selys)

1884. *Diplax commixum,* Selys, *Ann. soc. Ent. Belg.*
1936. *Sympetrum commixtum,* Fraser, *Fauna Brit. India* Odonata, 3 : 372
1954. *Sympetrum commixtum,* Santokh & Baijal, *Agra Univ. J. Res.* (*Sci*), 2 : 397, fig. 28, 29.

Santokh & Baijal, 1954. *Agra Univ. J. Res.* (*Sci*), 2 (3) : 393-394

1 female, Coll. No. 337/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas Manali, 6500 ft. Coll. V. K. Gupta, 23-vi-1955. Cardex 108 Sta. No. 3.

The specimen agree well with the description of the species. This species has previously been recorded from North and N. W. Himalayas, Abbotabad and from Yusimarg, Kashmir and recently from Gulmarg, Kashmir.

Suborder *ZYGOPTERA*

Family COENAGRIIDAE

Ceriagrion fallax (Ris)

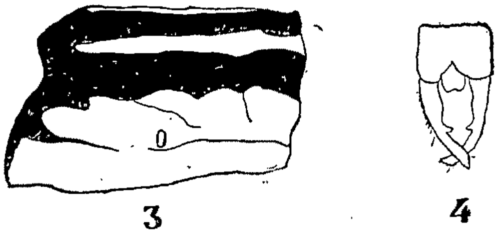
1914. *Ceriagron fallax*, RIS, *Ent. Mitteil.*, **3** (2) : 47-48
1933. *Ceriagrion fallax*, FRASER, *Fauna Brit. India*, **1** : 321-322.

3 males, Coll. No. 347/55, 341/55, 341/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain (Kulu) 5500 ft. Coll. V. K. Gupta, 24-vi-1955." Cardex No. 112. Sta. No. 42.

The specimen agrees well with the description of the species. This species is previously known from the hilly tracts of Assam, Simla Hills, Bengal Sikkim and from Tibet.

Archibasis sushmae, sp. nov. of H. N. Baijal

Male.—Abdomen 35 mm. Hind wing 25 mm. Labium yellow; labrum greenish-yellow; clypeus, frons and the occipital area black. Prothorax black mark with apple green stripe in the middle and bordered with brownish yellow stripe. *Pterothorax* fig. 3 black mark with apple-green as follows, mid-dorsal carina yellowish, antehumeral stripe apple-green, humberal suture black, mesepimeron and metepimeron apple-green, post-lateral suture and antero-lateral suture black. *Legs* black marked with brown. *Wings* hyaline, pterostigma black covering about 3 cells. About 12 postnodal nervure in fore wing and 13 postnodal nervure in hind wing. *Abdomen* dull greenish marked with black as follows. Segment 1 with dorsal blackish triangular spot and with a small lateral black spot, segment 2 with a black long



Archibasis sushmae, sp. nov. of H. N. Baijal Fig 3. Pterothorax of male Fig 4. Anal appendages of male.

lateral stripe and the segment 3, 4 and 5 with a basal dorso-lateral spot and the segment 6, 7 brownish in colour without any marking and the segment 8, 9, 10 brown except the lateral region which is somewhat apple green. *Anal appendages* (fig. 4) brownish-black, superior forcipate longer than segment 10, subcylindrical at base but compressed nearer apex and curving medialwards with an acute spine; inferior rounded very short, vestigeal not visible from above.

Female.—abdomen 33 mm. Hind wing 26 mm. very similar to male except the anal appendages which are brown, short and conical.

Holotype male, allotype female, Nos. 330/55, 361/55. "Prof. M. S. Mani School of Entomology Expeditition to Himalayas, Manali, 6500 ft." Coll. V. K. Gupta, 23- vi - 1955. Cardex No. 109, 115 & Sta. No. 3. In a paper envelope.

This species is near to *Archibasis mimetes paraeclara* Fraser[1] from which it can readily be distinguished by its body colour and anal appendages.

Enallagma cyathigerum (Charpentier)

1840. *Enallagma cyathigerum* CHARP. *Lib. Europ,* p. 163
1933. *Enallagma cyathigerum,* FRASER, *Fauna Brit. India* Odonata, **1** : 372-375.

1 female, Coll. No. 347/55, 1 damaged male, Coll. No. 341/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain (Kulu). 5500 ft. Coll. V. K. Gupta, 24-vi-1955." Cardex No. 112. Sta. No. 42.

This species agrees well with the description of the species. This species was previously recorded from Europe, Central Asia including Kashmir and Tibet, North America and the British Isles.

Section C. By Koshy Mathew*

Order HETEROPTERA

Family PENTATOMIDAE

Dolycoris bacearum (Linn.)

1761. *Cimex bacarum,* LINN. *Faun. Suec.,* **2** : 249, 928.
1902. *Dolycoris bacearum,* DISTANT, *Fauna Brit. India,* Rhynchota (Heteroptera), **1** : 159.

2 examples, Coll. No. 136. 1/55, 137. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Manali, River Beas Bank, Coll. V. K. Gupta, 31-VI-1955." Sta. No. 16, Cardex No. 32 & 34.

Basal segment and bases of remaining antennal segments yellowish, central lobe of head, lateral margins of pronotum, apex of scutellum, body beneath and legs luteous, apex of lateral lobes of head dark brown; apices of tibia and tarsus black, body pilose, black spots on femur and tibia. In all other characters the specimens agree well with the published description of the species. The species is previously known from Sind Valley, Kashmir and Bangalore. Common in the Palearctic regions.

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[1] FRASER, 1933, Fauna Brit. India, Odonata, **1** : 310-312.

*Part of the Hetcrpotera material included here was worked out in collaboration with Mr. S. S. Krishna, who was for some time associated with the School of Entomology.

Eurydema lituriferum (Walker)

1867. *Strachia lituriferum*, WALKER, *Cat. Het.*, **2** : 326.
1902. *Eurydema lituriferum*, DISTANT, *Fauna, Brit. India*, Rhynchota (Heteroptera) **1** : 191.

1 example, Coll. No. 349. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain. (Kulu). 6000 ft, Coll. V. K. Gupta, 24-VI-1955" Sta. No. 42, Cardex. 112.

The specimen agrees well with the published description of the species. Previously recorded from Sikkim, Assam, Margherita, Khasi Hills, Naga Hills, Burma Teinzo, Bhamo, China and Sumatra.

Eurydema festivum (Linn.)

1767. *Cimex festivum*, LINN., *Syst. Nat.* (10) **2** : 723.
1902. *Eurydema festivum*, DISTANT, *Fauna Brit. India*, Rhynchota (Heteroptera), **1** : 190.

1 example, Coll. No. 348. 11/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain (Kulu), 6000 ft., from bushes, Coll. V. K. Gupta, 24-VI-1955, between 10 A. M. and 4 P. M." Sta. No. 42, Cardex No. 112.

The specimen differs somewhat in colour. Body beneath coxae and bases of femora luteous, two series of orange-yellow spots on each lateral side of abdomen also in addition to two series of black spots, one central and one lateral. Previously recorded from Sind Valley, Kashmir, Maderra, Morocco, Eastern Turkestan, N. W. Siberia and Astracan.

Nezara viridula (Linn.)

1758. *Cimex viridula*, LINN., *Syst. Nat.*, (10) **1** : 444
1902. *Nezara viridula*, DISTANT, *Fauna Brit. India*, Rhynchota, **1** : 220

6 males and 4 females, Coll. Nos. 552. 2/55, 552. 3/55, 552. 4/55, 552. 5/55, 552. 6/55, 552. 7/55, 552. 8/55, 552. 9/55, 552. 10/55, 552, 11/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Manali, 6500 ft., Plantation along the River Beas" Coll. Santokh Singh between 9 to 11 A. M. Sta. No. 3, Cardex No. 110.

The specimens agree with the published description except that the extremity of the segmental angles to abdomen is not black but green. The body is uniformly dark green without spots. The species is common through out India, Palaearctic, Nearctic, Etheopean, large areas of Neotropical, Oriental and Australian regions.

Canthecona furcellata (Wolff)

1801. *Cimex furcellata*, Wolff., *Icones Cimicum deser illustr.*, 5 : 182, pl. xviii fig. 176
1902. *Canthecona furcellata*, Distant, *Fauna Brit. India*, Rhynchota, 1 : 248.

1 example, Chakrata, 7500 ft. Coll. Koshy Mathew, 22-ix-1953.

The specimen agrees well with the published description. Already recorded from Bengal, Calcutta, Ranchi, Bombay, Madras, Ceylon, Burma, Bhamo, Teinzo, Karennee and Java.

Zicrona caerulea (Linn.)

1758. *Cimex caerulea* Linn, *Syst. Nat.* (10) 1 : 445.
1902. *Zicrona caerulea*, Distant, *Fauna Brit. India*, Rhynchota, 1 : 225.

2 examples, Coll. No. 569. 2/55, 569. 3/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain (Kulu), 6000 ft., from Willow and Poplar " plantation along the bank of river Beas, Coll. Santokh Singh, 24-vi-1955" Sta. No. 42, Cardex No. 114.

Antennae, legs apex of abdomen pilose, tarsi and rostrum black. Previously recorded from Sind Valley, Kashmir, Bengal, Naga Hills, Burma, Karennee, Malaya Archipelago, China, Japan, Widely distributed in Palaearctic region.

Eusthenes rubefactus Distant

1901. *Euthenes rubefactus* Distant, *Trans. ent. Soc. London*, p. 111.
1902. *Euthenes rubefactus*, Distant, *Fauna Brit. India*, Rhynchota (Heteroptera), 1 : 267.

1 Male and 1 female, Ramgarh, 6000 ft., Coll. H. N. Baijal, 17-ix-1953.

The specimens before me agree well with the published description of the species. This is previously known from Burma and Karennee.

Sastragala rufispina Distant

1887. *Sastragala rufispina* Distant, *Trans. ent. Soc. London*, p. 353.
1902. *Sastragala rufispina*, Distant, *Fauna Brit. India* Rhynchota (Heteroptera), 1 : 319.

1 female, Coll. No. 569. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain (Kulu), 6000 ft., Coll., Santokh Singh, 24-vi-1955." Cardex No. 114. Sta. No. 42.

The specimen before me agrees well with the published description of the species. Previously recorded from North India.

Family COREIDAE

Prionolomia gigas Distant

1879. *Prionolomia gigas*, Distant, *Ann. Mag. nat. Hist.*, (5) 3 : 128.
1902. *Prionolomia gigas*, Distant, *Fauna Brit. India*, Rhynchota (Heteroptera), 1 : 337.

1 male, Ramgarh, 6000 ft., Coll. H. N. Baijal, 17-x-1952.

The specimen before me agrees well with the published describtion of the species. This is recorded previously from Khasi Hills, Burma and Karennee.

Elasmomia granulipes (Westw.)

1842. *Myctis granulipes,* WESTW., in *Hop. Cat.,* **2** : 11
1902. *Elasmomia granulipes,* DISTANT, *Fauna Brit. India,* Rhynchota (Heteroptera), **1** : 339.

1 example, Coll. No. 575. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Manali, 6500 ft., Willow plantation near Forest Rest House, Between 10 A. M. to 12-30 P. M., Coll. Santokh Singh, 25-vi-1955" Sta. No. 2, Cardex No. 116.

The body chestnut coloured, a white spot on each lateral side of the metasternum. In all other characters the specimen agrees well with the published description of the species. This species is previously known from Sikkim.

Cletus punctulatus (Westw.)

1842. *Coreus punctulatus,* WESTW. *in Hope Cat.,* **2** : 23.
1902. *Cletus punctulatus,* DISTANT, *Fauna Brit. India,* Rhynchota (Heteroptera), **1** : 392.

1 male, 552. 12/55. "Prof. M. S. Mani, School of Entomology Expedition to Himalayas, Manali, 6500 ft., Plantation along R. Beas, between 9 to 11 A. M. Coll., Santokh Singh, 23-vi-1955" Sta. No. 3, Cardex No. 110.

The specimen before me agrees well with the published description of the species. The species is prevously recorded from Sikkim, Kurseong, Khasi Hills ahd Naga Hills.

Family ARADIDAE

Subfamily BRACHYRHYNCHINAE

Brachyrhynchus tagalieus (Stal.)

1870. *Arictus tagalieus,* STAL., *Ofv. Vet.-Ak. Forh.,* p. 672.
1903. *Brachyrhynchus tagalieus,* DISTANT, *Fauna Brit. India,* Rhynchota, **2** : 162.

18 examples, 82.8/55, 82.9/55, 82. 11/55, 82.12/55, 82. 13/55, 82.14/55, 32. 15/55, 18. 16/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Pir Panjal range opposite Kulti Nal, 12,000 ft. Coll. Santokh Singh, 10-vi-1955. Sta. No. 26. Cardex No. 73.

The specimens before me agree well with the published description of the species. The species is previously known from Burma, Palaon, Teinzo, Katha, Philippines, Java and Nias Island.

Family PYRRHOCORIDAE

Subfamily Parginae

Physopelta gutta (Burm.)

1834. *Pyrrhocoris gutta*, BURM., *Nov. Act. Acad. Leip.* 16, (suppl.), 300, pl. lxi, fig. 10.
1903. *Physopelta gutta*, DISTANT, *Fauna Brit. India*, Rhynchota (Heteroptera) **2** : 97.

1 example, Coll. No. 590. 10/55, Prof. M. S. Mani School of Entomology Expedition to Himalayas, Dalhousie, Coll. V. K. Gupta & S. Singh, 29. vi. 1955.

The specimen before me agrees well with the published description of the species. The species is already recorded from Assam, Margherita, North Khasi Hills, Ceylon, Burma, Bhamo, Tenasserim, Myitta, Japan, W. Yunnan and Sumatra.

Family REDUVIIDAE

Subfamily Salyareatinae

Lisarda rhypara Stal.

1859. *Lisarda rhypara*, STAL., *Ofv. Vet.-Alk. Forth.* p. 192.
1873. *Reduveius argillaeeus*, WALK., *Cat. Het.* 7 : 195.
1903. *Lisarda rhypara*, DISTANT, *Fauna Brit. India*, Rhynchota, **2** : 238.

4 examples, Coll. Nos. 350. 8/55, 350. 9/55, 375. 3/55, 552. 14/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Manali, 6000 ft, Willow plantation near Rest House, Coll. Santokh Singh & V. K. Gupta, 24-vi- 1955." Cardex No. 115 & 116, Sta. No. 2.

The specimens before me agree well with the published description of the species. The species is previously known from Burma, Tenasserim, Penang and Java.

Subfamily Ectrichodiinae

Scarda militaris Distant

1909. *Scarda militaris*, DISTANT, *Ann. Soc. Ent. Belg.* **53** : 366.
1910. *Scarda militaris*, DISTANT, *Fauna Brit. India*, Rhynchota, **5** : 197.

1 example, Chakrata, 7000 ft., on plant, Coll. Sharda Singh, 20-ix-1953.

Reddish-ochraceous, antenna black, central portion of pronotum black. The lateral black band on the ventral later sides of the abdomen is as broad in posterior region as in front and connected together in the posterior region by a transverse black band. In all other characters the specimen does not differ from the published description of the species. The species is already recorded from Assam, and Naga Hills.

Section D. By V. K. Gupta

Order HYMENOPTERA

Superfamily *ICHNEUMONOIDDEA*

Family BRACONIDAE

Apanteles ruidus Wilk.

1928. *Apanteles ruidus,* WILKINSON, *Bull. ent. Res.* **19** : 94.
1935. *Apanteles ruidus,* BEESON & CHATERJEE, *Indian For. Rec.* (*N. S.*) *Ent.*, **1** : (6) : 117.

3 females, Coll. No. 353/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain, 5500 ft., ex. cocoons on peach leaf, Coll. V. K. Gupta, 26-vi-1955." Sta. No. 42, Cardex No. 112.

This species is previously recorded from Rohatgoan (Hoshangabad) and Dehra Dun from *Hapalia machaeralis* Walk. and *Pyrausta celatalis* Wlk. (Pyralidae).

A species of chalcid also emerged from some of the cocoons and therefore seems to be a hyperparasite of *Apanteles ruidus.*

Apanteles ferrugineus Marsh. (?)

1 ex. No. 185/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Kultinal, 11,500 ft., Coll. V. K. Gupta, 9-vi-1955, on low vegetation on a grassy patch." Sta. 128, Cardex No. 67

This specimen runs to *A. flavipes* Cam. in Wilkinson's key[1] and agrees with the description except for the presence of a longitudinal carina on the propodeum of which there is no mention by Wilkinson in the description of *A. flavipes* Cam. Bhatnager in his key to Old World species of *Apanteles*[2] mentions the presence of longitudinal carina on propodeum in *A. ferrugineus* to which the specimen runs. *A. ferrugineus* is an European species and has not been previously recorded from India.

Superfamily *SPHECOIDEA*

Family BEMBICIDAE

Bembix latitarsus (Handl.)

1893. *Bembex litetarsus,* HANDLIRSCH, *Sitzungsb. Akad. Wiss.* Wien, **52** : 707
1897. *Bembex litatarsus,* BINGHAM, *Fauna Brit. India,* Hymen., **1** : 289.
1955. *Bembix litatarsus,* MANI, et. al. *Agra Univ. J. Res.* (*Sci.*), **4** : 506.

3 females, Coll. No. 1 (64)/54, "Prof. M. S. Mani School of Entomology

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[1] WILKINSON, D. S. 1928-29. *Bull. Ent. Res.*, 19.

[2] BHATNAGAR, S. P. 1949. Ph. D. Thesis, Agra University.

Expedition to Himalayas, Thiroat, 9500 ft., Lahoul Valley, Coll. M. S. Mani and Santokh Singh, 9-vi-1954."

Previously recorded from "Himalayas," Mussoorie and Gilgit.

The specimens show variations from the published description in having the inner borders of eyes nearly parallel sides and not convergent below, in the absence of yellow line on pro-notum and the legs being entirely pale. Scape yellow and flagellum blackish.

Family SPHECIDAE

Ammophila laeata Bingham

1897. *Ammophila laeta*, BINGHAM, *Fauna Brit. India*, Hymen., **1** : 234.

4 examples, Coll. Nos. 170. 1/55, 170. 2/55, 170. 3/55, 170. 4/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Gramphu, 12,000 ft., Coll. V. K. Gupta, 8-vi-1955, near rocky places." Sta. No. 24, Cardex No. 62.

1 example, Coll. No. 313 14/55. "Prof. M. S. Mani, School of Entomology Expedition to Himalayas, Dhorni, 12000. ft., Coll. V. K. Gupta, 13-vi-1955 on Jam dropped on grass near camp site." Sta. No. 31, Cardex No. 77.

2 example, Coll. No. 317. 10/55, 317. 3/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Hamta Gorge, 12,000 ft., Coll. V. K. Gupta, 16-vi-1955, on vegetation." Sat. No. 35, Cardex No. 87.

1 example, Coll. No. 1 (3) 54. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Manali, 6000 ft., Coll. M. S. Mani & S. Singh, 1954".

Previously recorded from Afganistan : Chaman. The specimens were collected in sunshine. This is the first record of this central Asian species from India. These records extend the range for this species in the east. The abdomen is dark-reddish in some specimens while in others it is tinged black.

Family CRABRONIDAE

Crabro adrens Cameron

1890. *Crabo adrens*, CAMERON, *Mench. Mem.*, (4) **3** : 270.
1897. *Crabro adrens*, BINGHAM, *Fauna Brit. India*, Hymen., **1** : 325

1 female, Coll. No. 109/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla, 9000 ft., Coll. V. K. Gupta, 26-v-1955, on vegetation." Sta. No. 12, Cardex No. 16.

Previously recorded from Barrackpore and Bombay. This is the first record of the oriental species from the Himalayas. The specimen is 9 mm. in length, the usual size being 5 mm.

Crabro sp.

1 example, Coll. No. 122. 3/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla, 9000 ft., Coll. V. K. Gupta, 28-v-1955, on low vegetation" Sta. No. 12, Cardex No. 23.

This species differs from all the species described by Bingham in Fauna of British India volume. It comes nearer to *C. opifex* Bingham described from Calcutta.

Superfamily *VESPOIDEA*

Family VESPIDAE

Vespa velutina Lepel

Vespa velutina, LEPEL, *Lepel Hymen.*, **1** : 507.
1897. *Vespa velutina*, BINGHAM, *Fauna Brit. India*, Hymen., **1** : 405.

1 example, Coll. No. 138. 6/55. "Prof. M. S. Mani School of Entomology Expeditition to Himalayas, Marhi, 12,000 ft., Coll. V. K. Gupta, 1-vi-1955" Sta. No. 18, Cardex No. 34.

1 example, Coll. No. 313. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Dhorri, 12,000 ft., Coll. V. K. Gupta, 16-vi-1955." Sta. No. 31, Cardex No. 77.

3 examples, Coll. Nos. 317. 4/55, 317. 6/55, 317. 12/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Hamta Gorge, 12,000 ft., Coll. V. K. Gupta, 16-vi-1955." Sta. 35, Cardex No. 87. All collected on flowers on grassy patches.

The specimens exhibit variation in colour and differ from the published description in the following:

i. Transverse bands on abdominal tergites enlarged, ii. markings rather brownish yellow and iii. Post-orbital yellow markings variable.

Previously recorded from Kumaon, Sikkim, Burma, Tenasserim, China and Java. The present record extends the distribution in the Palaearctic Himalayas.

Family EUMENIDAE

Odynerus punctatum (Fabr.)

1804. *Polistes punctatum*, FABRICIUS, *Syst. Piez*, p. 273.
1897. *Odynerus punctatum*, BINGHAM, *Fauna Brit. India*, Hymen., **1** : 365.

2 females, Coll. Nos. 346. 1/55, 346. 2/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Kartrain, 5500 ft., Coll. V. K. Gupta 24-vi-1955." Caught from shady vegetation, mostly ferns. Sta. No. 42, Cardex No. 112.

Previously recorded from Barrakpore, Allahabad, Bombay and Bangalore. The specimens before me differ from the published description in having black colouration above antennal sockets, on the pronotum and on the third abdominal segment more prominent. The present record extends the distribution of this typical Oriental species to low elevations in N. W. Himalayas.

Odynerus sp.

1 example, Coll. No. 332. 12/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Manali, 6000 ft., Coll. V. K. Gupta, 23-vi-1955." Sta. No. 3, Cardex No. 109.

1 example, Coll. No. 346 3/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain, 5500 ft., Coll. V. K. Gupta, 26-vi-1955." Sta. No. 42, Cardex No. 112.

The specimens differ from all the species described by Bingham. (*loc. cit.*).

Family PSAMMOCHARIDAE (Pompilidae)

Pompilus ariadne Cam. (?)

1891. *Pompilus ariadne*, CAMERON, *Manch. Mem.* (4) **4** : 457.
1897. *Pompilus ariadne*, BINGHAM, *Fauna Brit. India*, Hymen., **1** : 159.

1 example, Coll. No. 122. 2/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla, 9000 ft., Coll. V. K. Gupta, 29-v-1955." Collected on vegetation in bright sunshine. Sta. No. 12, Cardex No. 23.

Previously recorded from Barrakpore and Tenasserim. The specimen differs from the published description in the abdomen being only very slightly compressed laterally, wholly black. The anterior margin of clypeus, antennae beneath, tarsi and posterior lateral calacarae blackish rather than testaceous. I am not entirely sure of this species.

Superfamily *APOIDEA*

Family BOMBIDAE

Bombus rufofaciatus Smith

1852. *Bombus rufofaciatus*, SMITH, *Trans. ent. Soc.*, **2** : 48.
1897. *Bombus rufofaciatus*, BINGHAM, *Fauna Brit. India*, Hymen., **1** : 547.

1 female, Coll. No. 320. 1/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Chhatru, 12000 ft., Coll. V. K. Gupta, 17-vi-1955."

Sta. No. 35, Cardex No. 95. Caught entering borrow in soil under stones. Some bushes surrounding the burrow. Bright sunshine, forenoon.

1 example, Coll. No. 1 (61) /54. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Namu 10,000 ft. Coll. M. S. Mani & S. Singh, 5, 7-vi-1954."

Previously recorded from Northern India, Sikkim, 12000 ft. Apparently a high altitude species common in the Himalayas.

Bombus haemorrhoidalis Smith

1852. *Bombus haemorrhoidalis*, SMITH, *Trans. ent. Soc.*, **2** : 43.
1897. *Bombus haemorrhoidalis*, BINGHAM, *Fauna Brit. India*, Hymen., **1** : 554.
1935. *Bremus (Orientalibombus) haemorrhoidalis*, FRISON, *Rec. Indian Mus.*, **37** :336.

1 example, Chakrata, Coll. Miss. Pillay, 20-x-1952. 2 examples, Ramgarh, Coll. H. N. Baijal, 17-ix-1952 & Koshi Mathew, 23-x-1953. 1 example, Kashmir : Srinagar, Sankarcharya Hills, 6000 ft. Coll. M. S. Mani.

Previously recorded from Ladak : Dras, Kargil & Leh; Sikkim above 7000 ft; Kumaon; Simla Hills; Nainital; Mussoorie; Almorah; Garhwal, West Himalayas, 7000 ft.

This is a species common in high altitudes of the Himalayas and probably also distributed in the Tibetan plateau of Central Asia.

Bombus funerarius Smith var. *binghami*, nov.

1897. *Bombus funerarius*, BINGHAM, *Fauna Brit. India*, Hymen. **1** : 551.

3 examples, Srinagar, Coll. M. S. Mani and S. Singh, 28-ix-1953; 1 example, Chakrata, Coll. Koshy Mathew, 23-ix-1953.

This variety which has been described by Bingham and not named is now named as var. *binghami*. This differs from the typical *B. funerarius* Smith[1] in having the apical three abdominal segments with bright orange red, not grey pubescence. The typical form has been previously recorded from Northern India : Kalipokri, 10,000 ft. and Calcutta. The variety *binghami* has been recorded from Sikkim, 8000 ft.

Bombus simillimus Smith

1852. *Bombus simillimus*, SMITH, *Trans. ent. Soc.*, 2 :48
1897. *Bombus simillimus*, BINGHAM, *Fauna Brit. India*, Hymen., 1 : 554

1 example, Coll. No. 1 (8) 54. "Prof. M. S. Mani School of Entomology Expeditition to Himalayas, Manali, 6000 ft., Coll. M. S. Mani and S. Singh, 25-v-1954."

Previously recorded from Northern India and China.

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[1] SMITH, 1852. *Trans. ent. Soc.*, 2 : 47.

Bombus [illegible]anurus Lepel

?. *Bombus melanurus*, LEPEL, *Lepel. Hymen.*, 550.
1897. *Bombus melanurus*, BINGHAM, *Fauna Brit. India*, Hymen., **1** : 550.
1955. *Bombus melanurus*, MANI., ét. al., *Agra Univ. J. Res.*, (Sci.), **4** : 508.

1 example, Coll. No. 551/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Manali, 6000 ft. Coll. Santokh Singh 2-vi-1955." Sta. No. 3, Cardex No. 110.

Previously recorded from Syria, Siberia, Ladak : Pangong Valley. Apparently a Central Asian species penetrating into India.

Family COLLETIDAE

Colletes sp.

1 male, Coll. No. 345. 1055." Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain, 5500 ft., Coll. V. K. Gupta, 24-vi-1955." Caught from shady vegetation mostly ferns. Sta. No. 42, Cardex No. 112.

The specimen before me differs considerably from the only other species *C. dudgeonii* recorded by Bingham in Fauna of British India Volume.

Section E. By Santokh Singh

Order LEPIDOPTERA

Family PIERIDAE

Pontia daplidice moorei (Röber)

1939. *Pontia diplidice moorei*, TALBOT, *Fauna Brit. India*, (*Butterflies*), **1** : 431.

1 Example Coll. No. 183. 2/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Kulti Nal, 11,500 ft., Chandra Valley; Coll. V. K. Gupta, 9 - vi - 1955." Sta. No. 28, Cardex No. 67.

Previously known from Baluchistan to Chitral and Punjab, Murree; not rare in irrigated areas at about 9,000 ft., Also found in Tibet and Yunnan.

Pieris rapae iranica Le Cerf.

1939. *Pieris rapae iranica*, TALBOT, in *Fauna Brit. India* (Butterflies), **1** : 428.

1 Example, Coll. No. 174. 2/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Gramphu, 12,000 ft., Coll. V. K. Gupta, 8- vi - 1955." Sta. No. 24, Cardex No. 62.

Previously known from Mesopotamia, and North Persia to Baluchistan, Chitral, Kashmir to Ladak.

The present collection extends the range of its distribution towards the South Eastern direction.

Pieris brassicae (Linn.)

1939. *Pieris brassicae,* TALBOT, in *Fauna Brit. India, (Butterflies),* **1** : 426.

2 examples Coll. Nos. 107/1/55, 131. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Rahla, 9000 ft., Coll. V. K. Gupta, 22 - v - 1955." Sta. No. 7, Cardex No. 16; and "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Marhi, 12,000 ft., Coll. V. K. Gupta, 1 - vi - 1955." Sta. No. 18 and Cardex No. 34.

Previously known from all over Europe to Turkestan, Baluchistan and Himalayas.

Colias croceus fieldi Men.

1785. *Papilio croceus,* FOURCRROY, *Ent. Paris,* **ii** : p. 250.
1855. *Colias fieldi,* MEN. *Cat. Mus. Ptr., Lep.* **i** : 79, pl. 1, fig. 5.
1907. *Colias croceus fieldi,* BINGHAM, *Fauna Brit. India (Butterflies),* **2** : 243, pl. xv,

1 Example, Coll. No. 183. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Kulti Nal, 11,500 ft., Chandra Valley; Coll. V. K. Gupta, 9 - vi - 1955" Sta. No. 28, Cardex No. 67.

Previously known from the Himalayas, from Chitral to Sikkim and Bhutan, from 2500 ft. to 14,000 ft., Extending to Assam, Upper Burma and China.

Colias ladakensis Felder

1865. *Colias ladakensis,* FELDER, *Novara Reise, Lep.,* **ii** . 197, pl. 27, figs. 8, 9,
1907. *Colias ladakensis,* BINGHAM, *Fauna Brit. India (Butterflies),* **2** : 236.
fig. 103.

3 Examples, Coll. Nos. 324. 1/55, 324. 2/55, 318. 2/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Chhatru, 12,000 ft., Chandra Valley; Coll. V. K. Gupta, 16-17. vi. 1955." Sta. No. 39, Cardex No. 95. and 2 examples Coll. No. 523. 1/55, 524. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Hamta Jot. 14,500 ft., Pir Panjal Range. Coll. Santokh Singh, 16. vi. 1955. Sta. No. 37 Cardex No. 93.

Previously known from Ladak and Kashmir, crossing over from Tibet and Chines Tartary.

Family NYMPHALIDAE

Argynnis claudia Fawcett

1904. *Argynnis claudia,* FAWCETT, *Abstr. P. Z. S.,* **9** : 8.
1904. *Argynnis claudia,* FAWCETT, *P. Z. S.,* **2** : 136, pl. ix, fig. 3,

1 Example, Coll. No. 525. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Hamta Jot, 14,500 ft., Pir Panjal Range; Coll Santokh Singh, 16. vi. 1955." Sta. No. 37, Cardex No. 93.

1 Example Coll. No. 318. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Near Chhatru, 11,500 ft., Chandra Valley; Coll. V. K. Gupta, 16. vi. 1955.," Sta. No. 34, Cardex No. 87.

2 Examples Coll. Nos. 174. 1/55, 538. 1/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas; Gramphu, 12,000 ft., Chandra Valley; Coll. V. K. Gupta & M. S. Mani, 8. vi. 1955 and 19. vi. 1955." Sta. No. 24, Cardex No. 62 and 99.

Previously known from, Khamba Jong, Tibet, 15,000 ft. The present collection extends its range of distribution into the N. W. Himalayas.

Section E. By H. N. Baijal

Order COLLEMBOLA

Suborder **Arthropleona**

Superfamily Mydonioidea

Family TOMOCERIDAE

Subfamily Tomocerinae

Tribe Tomocerini

Tomocerus ocreatus Denis

1948. *Tomocerus ocreatus,* Denis, *Mus. Heude Notes Ent. Chin.,* 12 (17) : 220 : 221. fig. 11.

Numerous examples. Coll. No. 4 (N) 55; 6 (N)/55; 7 (N) 55; 8 (N) 55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Narkanda, on Simla-Tibet Road between 154-158 miles near Sutlej Valley." 9,500 ft. Coll. H. N. Baijal, 4-10-1955".

Coll. No. 1/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla. 8,800 ft. Coll. Santokh Singh, 25-v-1955". Sta. No. 10 Cardex No. 10.

Coll No. 17/55, 29/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla. 10,000 ft. Coll. Santokh Singh, 27-v-1955". Sta. No. 14 Cardex No. 20 & 19.

Coll. No. 18/55, "Prof. M. S. Mani School of Entomology Expeditition to Himalayas, Rahla. 10,000 ft. Coll. Santokh Singh, 28-v-1955". Sta. No. 13. Cardex No. 24.

Coll. No. 35/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Marhi. 12,000 ft. Coll. Santokh Singh, 31-vi-1955". Sta. No. 18. Cardex No. 33.

Coll. No. 79/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Opposite Kulti Nal, Chandra Valley (Lahul). 12,000 ft. Coll. Santokh Singh, 10-iv-1955". Sta. No. 26. Cardex No. 73.

Coll. No. 202/55; 204/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Manali Rahla Road, 6000 ft. Coll. H. N. Baijal, 22-v-1955". Sta. No. 4 Cardex No. 3.

Coll. No. 212/55; 215/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla. 8,000 ft. Coll. H. N. Baijal, 25-v-1955". Sta. No. 10. Cardex No. 9.

Coll. No. 218/55; "Prof. M. S. Mani School of Entomology Expendituretions to Himalayas, Rahla. 8,000 ft. Coll. H. N. Baijal, 26-v-1955". Sta. No. 7 Cardex No. 15.

Coll. No. 222/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla. 8,500 ft. Coll. H. N. Baijal, 27-vi-1955". Sta. No. 8 Cardex No. 22.

Coll. No. 235/55; 235/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla." 9,500 ft. Coll. H. N. Baijal, 29-v-1955. Sta. No. 12. Cardex No. 27.

Coll. No. 236/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Marhi. 11,000 ft. Coll. H. N. Baijal, 31-v-1955". Sta. No. 12 Cardex No. 31.

Coll. No. 242/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rhotang Pass. 13,500 ft. Coll. H. N. Baijal, 4-vi-1955". Sta. No. 21. Cardex No. 39.

Coll. No. 247/55; 250/55; "Prof. M. S. Mani School Of Entomology Expedition to Himalayas, Gramphu. 12,000 ft. Coll. H. N. Baijal, 7-vi-1955". Sta. No. 25. Cardex No. 49.

Coll. No. 265/55; 269/55; 274/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Gramphu. 12,000 ft. Coll. H. N. Baijal, 8-vi-1955." Sta. No. 24. Cardex No. 61.

Coll. No. 402/55;" Prof. M. S. Mani School of Entomology Expedition to Himalayas, Chhatru. 11,500 ft. Coll. H. N. Baijal, 15-vi-1955." Sta. No. 35. Cardex No. 80.

Coll. No. 511/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Kote (Kulu valley). 7,500 ft. Coll. Santokh Singh, 20-vi-1955." Sta. No. 6 Cardex No. 105.

Coll. No. 513/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Peak to the west of Rohtang Pass. 15,000 ft. Coll. R. V. Charley, 19-vi-1955." Sta. No. 20. Cardex No. 100.

Coll. No. 517/55; "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Chhatru—Purana Khoksar Nal. 12,500 ft. Coll. Santokh Singh, 17-vi-1955." Sta. No. 41. Cardek No. 97.

This species was originally described from a single specimen taken in the tropical forests of Indo-China by Denis. The large series of specimens before me differ in the mesial teeth of claw varying from 2 to 6 and the mesial teeth of the mucro varying from 2 to 9; spines on the dentes in my specimens agree with the figure by Denis except that some of the basal spines are little larger.

This is the first record of the species from India. The species extends from the tropical forests of Indo-China to the N. W. Himalayas.

FAMILY MYDONIIDAE

Subfamily Mydoniinae

Tribe Mydoniini

Sinella montana Imms

1912. *Sinella montana* IMMS, *Proc Zool. Soc. London*, pl. viii fig. 48, pl. ix figs. 56, 57 pp. 101-102.

1929. *Sinella montana*, HANDSCHIN, *Rev. Suisse Zool* **36** : 238-239.

Numerons examples. Coll. No. 53/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Kulti Nal (Gramphu) Coll. Santokh Singh, 6-vi-1955" Sta. No. 25, Cardex No. 45.

Coll. No. 66/55 "Prof. M. S. Mani School of Entomology expedition to Himalayas, Kulti Nal, Changra Valley. 11,600 ft. Coll. Santokh Singh, 9-vi-1955" Sta. No. 28 Cardex. No. 69

Coll. No. 85/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Dhorni, left bank of river Chandra, 12,000 ft., Coll. Santokh Singh, 13-vi-1955" Sta. No. 32, Cardex No. 78

Coll. 98/55; 94/55. "Prof. M. S. Mani School of Entomology Expendition to Himalayas, Near Chhatru on meadow on the left bank of Chandra just below Hamta, 12,000 ft. Coll. Santokh Singh, 15-vi-1955." Sta. No. 35, Cardex No. 83.

Coll. No. 206/55 "Prof. M. S. Mani School of Entomology Expeditition to Himalayas, left side of river Beas, Rhotang road, upto 2 miles from Beas bridge, 6500 ft., Coll. H. N. Baijal, 24-v-1955." Sta. No. 4 Cardex No. 7.

Coll. No. 214/55, 219/55, "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla, on Kothi Rahla Road near Beas river, 8800 ft. Coll. H. N. Baijal, 25-v-1955 and 26-v-1955." Sta. No. 7 Cardex No. 15.

Coll. No. 222/55; 223/55; 225/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla, 8800 ft. Coll. H. N. Baijal, 27-v-1955." Sta. No, 8, Cardex No. 22.

Coll. No. 228/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Pir Panjal side on Rohtang Road, 9500 ft., Coll. H. N. Baijal, 28-v-1955." Sta. No. 11 Cardex No. 26.

Coll. No. 235/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, east of Rahla southern spur of Rohtang, 9000 ft., Coll. H. N. Baijal, 29-v-1955." Sta. No. 12. Cardex No. 27.

Coll. No. 239/55; 240/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Marhi, PWD gang hut, 12,000 ft., Coll. H. N. Baijal, 2-vi. 1955." Sta. No. 18, Cardex No. 13."

Coll. 249/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Gramphu opposite Kulti Nal on way to the valley, 11,500 ft. Coll. H. N. Baijal, 7- vi. 1955." Sta. No. 25, Cardex No. 50.

Coll. No. 266/55; 269/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Chandra Valley, Gramphu opposite Kulti Nal, 12,000 ft. Coll. H. N. Baijal, 8-vi-1955." Sta. No. 25 Cardex No. 60, 61.

Coll. No. 276/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Kulti Nal, Chandra Valley, 11500 ft. Coll. H. N. Baijal, 9-vi-1955." Sta. No. 28, Cardex No. 65.

Coll. No. 294/55, 295/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Dhorni, 12,000 ft. Coll. H. N. Baijal, 13-vi-1955." Sta. No. 31, Cardex No. 76.

Coll. No. 401/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Chhatru on meadow on the left bank of river Chandra just below Hamta Gorge, 12,000 ft. Coll. H. N. Baijal" Sta. No. 35 Cardex No. 80. Coll. No. 409/55 "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Baby Pass, West of Hamta Gorge on Pir Panjal, 14000 ft. Coll. H. N. Baijal," Sta. No. 38 Cardex No. 94.

This species was originally recorded from ant's nest under stones on a mountain side near Badrinath, Garhwal Himalayas, 10300 ft. It was also recorded by Handschin from Coonor, Kateri Valley (Nilgiris) S. India from ant's nest under stones. This is the first record of the species from the N. W. Himalayas.

Drepanosira subornata (Denis)

1936. *Parasira subornata* DENIS, *Mem. Conn. Acad. Art. & Sci.*, 10 : 267.

40 Examples. Coll. No. 402/55; 404/55; 405/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Hamta Gorge, 11500 ft. Coll. H. N. Baijal, 15-vi-1955." Sta. No. 34, Cardex. No. 80.

Coll. 223/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Rahla, Coll. H. N. Baijal, 27-v-1955" Sta. No. 8, Cardex No. 22.

Coll. 562/55. "Prof. M. S. Mani School of Entomology Expedition to Himalayas, Katrain, 5500 ft., Coll. Santokh Singh, 24-vi-1955." Sta. No. 42, Cardex No. 113.

This species was originally described from Dambu guru, Ladak, 4603 m, Takht-i-Sulaiman, Srinagar, 1585 m. Kashmir. I collected this species mostly from dry bank of river Chandra just below Hamta Gorge. The colour of the specimen was very much that of stones from which they were picked up. The specimens agree well with the published description of the species.

Section F. By Santokh Singh

DESCRIPTIONS OF STATIONS

STA. 1. Torrent below old Manali village; at end of Solang Valley : near wooden bridge under submerged boulders, 6,500 ft., above mean sea level. Subalpine forest with deodars on hill slopes.

STA. 2. Willow plantation in compound of Forest Rest House near a slow stream in new Manali, to the right of River Beas, surrounded by subalpine forest, 6,500 ft.

STA. 3. Plantations of willow and *Anlus nitida* on right bank of R. Beas, 1 mile south of Manali PTO on Manali-Kulu Road. Forest floor with dense stinging nettle and some wild barberry, 6,400 ft.

STA. 4. Slopes of hills on left bank of R. Beas opposite Manali, and 1-1/2 miles north of Manali bridge on Manali-Kote route upto Bashisht Sulpher spring. Covered by Alnus, poplar, elm etc., 6,600 ft.

STA. 5. Meadow with hillspur to the east on left bank of R. Beas, 1 mile south of Manali bridge on Manali-Hamta mule track. Cultivated. Ferns, nettle, 6,500 ft.

STA. 6. Nulla beneath a craggy spur and to the south-east of Kote PWD Rest House, running north-south, covered by ferns etc. Cultivated fields nearby. Conifers higher up. Altitude 7500 ft.

STA. 7. Camping Ground near wooden bridge slightly to the east of it, left bank of R. Beas, 1/2 mile to the west of Rahla Forest Inspection Hut. Covered with large stones and sheep dung and fallen leaves. Damp, shady with a slow stream on the south, a hill slope covered by broad leaved trees. Floor covered by buttercups, Potentilla etc., 8,800 ft.

STA. 8. Camping ground opposite station 7 on right bank of R. Beas, partly meadow. Exposed, sunny, relatively dry. Rock wall with water fall, a slow stream cutting through. No trees. Damp and moss covered ledges in rocky wall, 8800 ft.

STA. 10. River Beas near Rahla Forest Inspection Hut, with large boulders and stone. Current very fast clear during the night, morning, fore-noon and most past of afternoon but often more or less turbid later. Exposed to direct sun during the mid day. Altitude 8835 ft.

STA. 11. Slopes below alpine meadow south of Rohtang Pass about half a mile by short cut from Rahla Forest Inspection Hut. Boulders, stream, moss with a large cave used by shepherds. Exposed, 9,500 ft.

STA. 12. Grassy meadow to the east of Rahla Forest hut on right bank of R. Beas near its sharp curve from N-S to E-W course. Exposed, sloping, 9,000 ft.

STA. 13. Snow line on rocky precipice at the curve of river Beas, western aspect, on southern spur from the east of Rohtang Pass, covered with dwarf birch still under several feet of snow. High altitude bush rhododendrons sparse. Altitude 10,500 ft.

STA. 14. Meadow on a ridge on the left bank of river Beas, opposite Rahla Forest Inspection Hut, with subalpine vegetation all round. Torrential stream runs through the meadow down to the river. Exposed and windy. Altitude 10,500 ft.

STA. 16. Right bank of R. Beas near source just below Rohtang Pass with boulders and stones, exposed windy, 11,000 ft.

STA. 18. Alpine meadow in terraces at point of bifurcation of mule track to Rohtang and foot path to the frozen lake, facing south. Exposed, high glare, windy covered by snow in winter. With alpine flowers such as primulas in summer. Numerous streams. PWD Gang Hut at one end, 12,000 ft.

STA. 20. Snow covered summit of a mountain overlooking Sta. 18 & 19 and to the south of the Beas Rikhi Peak, somewhat east of Sta. 19. Windy. Glare high. Air temperature in the open at 1 P.M. on May 31, 1955 was 2°C in bright sunshine. Altitude 15,194 ft.

STA. 21. Summit of Rohtang Pass near the camp at base of Beas Rikhi Peak and close to the northern edge of the pass. A vast desert of snow. Windy. Exposed. High glare. Altitude 13,300 ft.

STA. 24. Gramphu Camping ground on alpine meadow on left bank of R. Chandra below Rohtang, a little to the west of opposite Kulti Nal. 3 miles east of Khoksar, 500 ft. above river bed. Numerous glacial torrents. Alpine vegetation esp. primulas butturcups, 11,000 ft.

STA. 25. Slope below Rohtang and about 1 mile to the east of station 24, with boulders, alpine flowers. Exposed. Torrents. North aspect, 11,200 ft.

SAT. 26. Slope east of station 25, about two miles to the east. Northern aspect with bush Rhododendrons, dwarf Birch, Juniper etc., snow line, steep, torrent, 12,000 ft.

STA. 28. Meadow near mouth of Kulti Nal and right bank of R. Chandra, east of a sloping spur, camping ground, alpine flowers, torrents, 11,300 ft.

STA. 29. Meadow to the west of station 28 at mouth of Kulti Nal. Similar to 28 with some stagnant water.

STA. 31. Dhorni camping ground 4 miles east of Gramphu C. G. Left bank of R. Chandra, near PWD Gang hut, barren, exposed, Snow covered, avalanche debris, 12,000 ft.

STA. 32. Slopes 1 mile east of station 31. Alpine flowers, edge of snow, 12,000 ft.

STA. 34. Sandy and stony meadow at R. Chandra level, opposite the site of new bridge on left bank, 5 miles east of station 31 and 1 mile west of Hamta Gorge, somewhat to the west of opposite Purana Khoksar Nal, with a rocky precipice on the south and a glacier on west, suny exposed, warm ground littered with avalanche debris, 11,000 ft.

Sta. 35. Shepherds Camping Ground on alpine meadow, sloping, left bank of R. Chandra at entrance to Hamta Gorge, 1 mile east of station 34. Exposed, boulders and stones glacial torrents, 11,200 ft.

Sta. 37. Snow fields on Northern aspect of Hamta Jot, a few boulders free of snow covered by lichen and moss, 5 miles south of station 34, and to the east of Hamta Pass, 14,500 ft.

Sta. 38. Snow fields on an unchartered narrow pass at 14,000 ft. above and to the south of station 34, reached by way of glacier described in station 34, with peaks on either sides rising to about 16,000 ft. Boulders left bare of snow with lichen and moss.

Sta. 39. Extensive alpine meadow in right bank of R. Chandra at entrance to Purana Khoksar Nal, opposite station 34 and about 50 feet above the river bed, with torrents running through Camping Ground with PWD Rest House.

Sta. 41. Site 2 miles up from the entrance in in the Purana Khoksar Nal. with pair of rocky abutmants from the east and west, with torrential meandering stream in between. Barren rock. Just beneath the Ice Fall Mountain of Seri. Altitude 12,500 ft..

Sta. 42. Willow plantation, and cultivated fields on the right bank of R. Beas near Katrain (Kulu), opposite the Katrain Trout Research Centre, undergrowth with stinging nettle and grass, 5,500 ft.

STUDIES ON THE EFFECT OF CHLORIDE AND SULPHATE OF SODIUM ON GERMINATION, GROWTH AND MATURITY OF GRAM

By S. N. Bhardwaj and I. M. Rao, *Botany Department, Agra College, Agra.*

Introduction

In the semi-arid regions of India and elsewhere, vast areas of land are rendered fallow due to high salinity or alkalinity of the soil. Desai and Sen (2) have reported for soils from Pusa, Bihar, as high as 0.023% chloride (on oven dry-weight of soil) and 0.269% sulphate of sodium from alkaline patches and 0.017% and 0.026% of the two salts from normal areas in the topmost layer (0-6″) of soil. From Karnal area Sen (16) estimated 0.064%, 0.146% and 0.029% of chloride and 0.118%, 0.212% and 0.15% of sulphate of sodium from alkaline, saline and normal areas respectively. In Jumna Khadar area 0.150% of chloride and 0.073% of sulphate have been reported by Raychaudhari and Tripathi (13). Attempts are made to reclaim these saline and alkaline areas by sowing crops or their varieties which could grow profitably under such adverse conditions, and also by soil amelioration methods.

Harter (6) investigated the effect of low and high concentrations of NaCl on wheat. Lipman and Gericke (11) studied the effect of NaCl and other salts of Sodium varying from 0.1% to 0.35% on growth of barley. Maintaining the optimum supply of water, low concentrations were stimulative, while those above 0.3% were definitely toxic in the case of sodium chloride.

During the previous decade much work has been carried on plant growth relations in alkaline and saline soils. Magistad (10) pointed out that reduced growth in saline soils is due to high osmotic pressure of the soil solution. Eaton (3) noted, in sand cultures, a decrease in growth of salt-tolerant crops with increase in the osmotic pressure of the culture solution. He also noted that sulphate appeared to be about half as toxic as chloride. On the contrary, Magistad, Ayers and Gauch (8) hold that chloride and sulphate when compared on equal osmotic pressure basis, depressed the growth almost to an equal extent. Similar conclusions have been made by Gauch and Wadleigh (17) for bean plants. Recently Rao (12) observed that growth and maturity of gram plants were adversely affected by NaCl, even in 0.05% concentration, Bhardwaj (7) noted that total dry weight of shoots of gram at harvest apparently decreased with salt (NaCl) added to the soil.

It is generally known that the adverse influence, on germination and growth of plants, of total dissolved salts or even a single salt like sulphate or chloride of sodium in soil will be enhanced as the amount of soil water decreases. This result is considered to be due to increase in the osmotic concentration of the soil solution or to the toxic effect of the increased concentration of the single salt. In the present studies, the effect of adding NaCl and Na_2SO_4 in two concentrations (0.05% and 0.1% on air dry-weight of soil) on germination, growth and maturity of a salt-susceptible crop (gram) has been investigated in pot cultures. The plants were subjected to four periods of soil drought (reduction of soil water content from field capacity to about 6%) during the growth stage, in order to understand the effect of the drought and also of the consequent increase in the concentration of the soil solution, on growth and maturity of the plants.

METHODS AND MATERIALS

Earthen pots (9″×9″) were filled each with 5 lbs. of air dry soil mixed with compost (1 : 1) and were watered thoroughly. Chloride and sulphate of sodium in the two doses (0.05% and 0.1% on air dry weight of the soil) were added to the respective pots in solution immediately after sowing gram N. P. 58 seeds (10 per pot) on 3rd November, 1953. Necessary precautions were taken to collect the percolating soil solution from pots and to add it back to the same. Four weeks after sowing, seedlings were thinned to four in each pot.

During the period of vigorous growth (8th to 12th week after sowing), one set of plants was subjected to permanent wilting stage four times, while optimum water supply was maintained throughout in the other set. Till the beginning of the soil droughts (8 week stage), there were ten pots for each treatment; for the soil drought series, 5 pots were selected at random from each set of 10 and the remaining 5 were continued with optimum water supply. At the end of 12 week stage, the drought series were also brought to continuous optimum watering till maturity. Thus five replications (5 pots) were maintained for each treatment including the controls from the 8 week stage to maturity. The following observations were recorded : (i) germination (ii) height of the tallest shoot, number of green leaves and number of branches at four weekly intervals upto maturity; (iii) shoot-dry-weight at 4-week stage; (iv) date of flowering; (v) dry weight of the shoots at harvest; (vi) yield; and (vii) 1,000 seed-weight.

The results on observations upto the beginning of drought (8 week stage) were statistically analysed according to Analysis of Variance, with 10 replications and 5 treatments; later observations with 5 replications were analysed on Factorial basis with d. f. for 'soil moisture' : 1; for salt treatments : 4; for the interaction : 4; and for the error : 40, total : 49.

EXPERIMENTAL RESULTS

The results on germination and growth upto 8 week stage (beginning of soil drought) are included in Table I. The later observations are given in Tables II and III. Mean values along with the respective critical differences are shown for each observation.

Germination : Final counts were taken four weeks after sowing (at the time of thinning). It was noted that neither of the doses nor the two salts inhibited germination.

Growth at 4 week stage : Relative to control, height was reduced by 8.3% and 21.5% with 0.05% and 0.1% doses of NaCl; and by 13.3% with 0.1% doses of Na_2SO_4, while with the lower dose (0.05%) of this salt height was as good as in the control. Unlike height, leaf number as well as number of branches were lowered more by either dose of sulphate (7.8 leaves, 2.5 branches per plant in 0.05% and 8.0, 2.6 in 0.1%) than those of chloride (9.0, 3.0 and 8.5, 2.7); the control had 10 leaves and 3.6 branches per plant. The shoot dry-weight per plant was greatly reduced by the higher dose of chloride (0.039 gm.) and by both the doses of sulphate (0.41 gm in 0.05% concentration and 0.036 gm. in 0.01%) as compared to the control (0.054 gm.)

Growth at 8 week stage : The downward trend for height continued with either of the chloride doses (15.2 cms. and 14.2 cms.); the control plants were 18.1 cms, tall. There was no significant reduction in height with the sulphate doses (18.1 cms. and 17.0 cms.) thus indicating that the earlier injurious effect of the higher dose of sulphate disappeared at this stage. However, the leaf and branch number showed the same trend as exhibited at the 4 week stage with the two salts and their doses.

TABLE I

Effect of NaCl and Na_2SO_4 on germination and early growth.

	Salt treatments					
		NaCl		Na_2SO_4		
Observations	Cont.*	0.05%	0.1%	0.05%	0.1%	C. D.
Germination % (Mean of 10 pots)	90	93	91	94	90	-
Growth (mean per plant-replications: 10 pots)						
4-week stage:—						
Height (cms.)	8.4	7.2	6.6	8.4	7.0	0.7
Leaves (No.)	10.0	9.0	8.5	7.8	8.0	0.8
Branches (No.)	3.6	3.0	2.7	2.5	2.6	0.3
Shoot dry-wt. (gm.)	0.054	0.050	0.039	0.041	0.036	0.007
3-week stage:—						
Weight (cms.)	18.1	15.2	14.2	18.1	17.0	1.4
Leaves (No.)	39.4	31.6	30.5	37.1	24.4	3.7
Branches (No.)	3.8	3.2	3.2	2.7	2.3	0.4

Observations on growth from the 12-week stage (end of the 4-week soil drought period) onwards are tabulated according to the main factors, 'salt-treatments' and 'soil moisture' (Table II) and their interaction (Table III).

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*Control (without any salt added to the soil).

Growth at 12-week stage.—From 8th to 12th week stage, one set of plants was subjected to permanent wilting condition four times by stopping watering; and the plants were recovered again on each occasion by watering the pots. The plants subjected to soil drought showed, in general, poorer growth than their controls.

Irrespective of the 'soil moisture,' height continued to be lower with the chloride doses (26.5 cms and 23.7 cms Table II), and was significantly lower with the sulphate doses (24.2 cms and 24.5 cms.) than the control (29.5 cms.). Thus apparently, the chloride was deleterious from the beginning, while the sulphate became so by about maturity. The leaf and branch number showed similar trends as in the earlier stages.

Irrespective of the salt-treatment, soil drought reduced the growth considerably (Table II), particularly the leaf number.

Considering the interaction-effect (Table III), the branch number, which alone was significant, was not affected by the chloride doses in the 'drought' set.

Flowering.—The soil drought enhanced flowering in gram by about 2.8 days, irrespective of the salt-treatments. Under optimum conditions of watering, flowering was delayed by about 6.4 days with either dose of sulphate; and by 2.2 days (not significant) and 4.8 days with the 0.05% and 0.1% of chloride. The above noted delay in flowering, due to salts in the optimum water-supply sets, was not observed in the 'drought-sets.'

TABLE II

Effect of the 'salt-treatments' and 'soil-moisture' on growth and maturity of gram.

	Salt-treatment						Soil moisture		
Observation	Cont.**	NaCl		Na_2SO_4		C. D.	Opt+.	S. D.*	C. D.
		0.05%	0.1%	0.05%	0.1%				
	Growth : (mean per plant-replications : 5 pots)								
12 week stage:									
Height (cms.)	29.5	26.4	23.7	24.2	24.5	2.5	27.4	23.9	2.1
Leaves	42.0	39.8	35.1	28.0	25.7	4.1	46.5	21.7	3.3
Branches	4.2	4.2	3.2	2.6	2.3	0.6	3.8	2.8	0.5
Flowering (days)	82.2	83.5	83.9	84.1	86.2	0.0	85.2	82.4	2.5
Maturity stage:									
Height (cms)	36.0	31.4	30.8	32.7	28.4	2.6	33.3	30.4	2.1
Leaves	58.2	49.7	40.8	42.7	41.3	6.5	55.3	37.8	5.3
Branches	8.3	6.3	4.8	5.3	5.4	0.7	6.6	5.4	0.6
Shoot dry wt. (gms.)	0.984	0.773	0.756	0.719	0.627	0.086	0.919	0.624	0.070
Yield (gms.)	1.501	1.063	1.027	0.766	0.671	0.394	-	-	-
1,000 seed wt. (per pot)	105.3	99.4	93.9	93.4	88.2	7.5	-	-	-

*Soil droughts (8th to 12th week).

**Control

+Optimum

Table III. Effect of 'soil moisture × salt-treatments' on growth and maturity of gram.

Observations	Optimum water supply throught					Soil droughts from 8th to 12 weeks after sowing					
	Cont.*	NaCl		Na_3SO_4		Cont.*	NaCl		Na_3SO_4		C. D.
		0.05%	0.1%	0.05%	0.1%		0.05%	0.1%	0.05%	0.1%	
	Growth : (Mean perXp plant-replications : 5 pots)										
12—week stage :—											
Height (cms)	32.3	28.5	24.7	26.5	25.1	26.6	24.4	22.6	22.0	23.9	...
Leaves	59.2	55.2	48.3	36.0	34.0	24.8	24.3	21.9	20.0	17.4	...
Branches	5.4	4.9	3.4	2.8	2.6	3.0	3.6	3.0	2.4	1.9	0.8
Flowering (days)	81.2	83.4	86.0	87.6	87.6	83.2	83.6	81.8	80.6	84.8	4.4
Maturity stage :											
Height (cm)	39.5	32.4	33.5	32.7	28.4	32.4	30.4	28.2	32.7	28.3	3.6
Leaves	69.6	64.1	52.0	47.5	43·7	47.4	35.2	29.5	37.9	38.8	9.2
Branches	9.8	7.4	5.7	5.2	5.0	6.8	5.2	3.9	5.5	5.7	1.0
Shoot-dry-weight	1.170	0.967	1.091	0.766	0.604	0.799	0.579	0.421	0.672	0.650	0.122
Yield	1.501	1.063	1.027	0.766	0.671	...	...	...	...	...	0.394
1,000 seed-wt. (per pot)	105.3	99.4	93.9	93.4	88.2	...	...	...	...	...	7.5

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*Control

Growth at maturity stage.—Trends, similar to those of 12 week stage, seem to have continued for height, leaf and branch number. However, in the drought set, the apparent stimulation in branch number with the lower dose of chloride observed in the previous stage, did not continue, while at maturity a significant fall was obvious (6.8 and 5.2 for control and 0.05% chloride respectively).

Shoot dry-weight.—Both the soil drought and the salt treatments affected the total dry-matter produced. Chloride (0.765 gms. Table II) was significantly less detrimental than sulphate (0.627 gms.) in the higher dose; while in the lower dose (0.05%), there was no significant difference between the two salts. The soil drought, irrespective of salt-treatment, depressed the shoot dry-weight. Considering the interaction of the two factors, which was also significant, it seems certain that sulphate (0.766 gms. and 0.604 gms. for shoot dry-weight with 0.05% and 0.1% of salt) was more toxic than the chloride (0.967 gms. and 1.091 gms.) under optimum condition of the water supply while with the soil drought, the relation was reversed i. e. chloride (0.579 gms. and 0.421 gms.) was more toxic than the sulphate (0.672 gms. and 0.650 gms.).

Yield and quality of seed.—Unfortunately, yield of seeds was available only for the optimum water-supply set. The sulphate gave lower yields (0.766 gms. and 0.671 gms.) than the chloride (1.063 gms. and 1.027 gms). The quality was, no doubt, inferior to the control in the treated sets, again a similar relationship holds good for quality as for yield regarding the relative influence of the sulphate and chloride.

DISCUSSION

Soluble salts in soil solution can have two types of effect on the growing plants : viz., specific injurious effects due to particular ion they contain and a general effect due to raising of the osmotic pressure of the solution around the roots. Magistad (10) was of the opinion that the reduced growth in saline soil would be due to high osmotic pressure of the soil solution. Similar conclusions were drawn by Hayward and Spurr (7) Rosene (14) and Eaton (3).

In the present experiment, a salt-susceptible crop (gram) has been selected; and its behaviour both under optimum water supply and under soil drought (8th to 12th week after sowing) has been studied.

Under optimum water supply.—Growth, in general was affected by the added salt. The decreases in heights was more or less the same for the two salts. The leaf number as well as the branch number were affected more by the sulphate than by the chloride; a similar trend was observed for shoot-dry-matter and also the yield. The differences due to the doses of either chloride or sulphate were not generally significant. Limpman and Gericke (11) observed a stimulating effect of NaCl on growth of barley with concentrations upto 0.03% (on oven dry soil). It may be pointed out that barley is decidedly more salt-tolerant crop than gram. Rao (12) observed that a concentration of 0.5% NaCl (on oven dry weight of soil) at 13% soil moisture was equivalent to an osmotic pressure of less than 2 atoms. Even this small increase in concentration of the soil solution due to the added salt resulted in 50% decrease in the total dry matter of gram plants. In the present experiment, at 20% soil moisture level, (mean percentage soil moisture maintained in these pots), the osmotic pressures developed for 0.05% and 0.1% concentrations (on air dry soil) would be about 0.17 atoms. and 0.37 atoms. for sulphate and 1.03 atoms. and 2.06 atoms. for chloride. The reduction in total dry matter produced in shoct was only 17.4% for 0.05% NaCl (Osmotic pressure=1.03 atoms.), much lower than the value cf 50% observed by Rao (12). This difference seems to be due to the maintainance of relatively lower moisture supply (13%) in the latter's experiment and also of the consequent increase in osmotic pressure to two atmospheres. However, Gauch and Wadleigh (5) recorded 12.7% loss with nearly the same osmotic concentration of NaCl (1 atoms.) for bean plants which, like gram and pea, are apparently salt sensitive. The same authors noted 13.9% decrease with the same concentration (8 atoms.) Of Na_2SO_4 solution. In the present studies, 34.6% and 48.4% reduction in shoot-dry-weight was recorded with 0.37 atoms. (0.05%) and 0.74 atoms. (0.1%) osmotic concentrations of Na_2SO_4.

Yield was lowered by 29.2% and 31.6% with the two doses of NaCl and 49.0% and 55.3% with those of sulphate.

Under soil drought.—The plants were brought to permanent wilting stage four times when they were 8 to 12 weeks old. Magistad and Reitmeir (1942), while studying the effect of soil solution concentration at the wilting range on growth of different crop plants, observed the suction tension of the soil reaches about 15 atoms. at this stage. They pointed out that an osmotic concentration equivalent to about 2 atoms. did not significantly affect the growth of the plants, while most of the crops suffered heavily with an osmotic concentration of about 10 atoms. In the present study, the shoot dry weight was reduced by 31.7% by soil drought alone, 50.5% and 64.0% by the two doses of NaCl and 42.6% and 44.4% by those of Na_2SO_4. The osmotic concentration in all the treatments were either 2 atoms. or less. Rao (12) also observed a loss of about 55% with NaCl solution of about 3 atoms. osmotic concentration (i. e. with 0.05% NaCl on oven dry soil with soil moisture at 8%).

General.—Wadleigh and Ayres (17) pointed out that without addition of salt to the soil, growth was reduced as the suction of the soil water increased. With low, medium or high suction, there was progressive decrease in the growth with increase of salt content of the soil. Magistad (1943) also stated that growth reduction in most cases was linear with increasing concentration of the substrate; when sulphate and chloride salts are compared on an equal osmotic basis, they caused approximately equal growth depression with a number of crops. In the present studies, two salts, having the same basis radical (Na^+) and different acid radicals (Cl^- and $SO_4^{=}$) were used. The osmotic concentrations of chloride were relatively higher than those of sulphate; even then it seems clear from the data that sulphate was more deleterious to growth than chloride under optimum water supply. Besides the osmotic effect, toxic effect of single salts has been pointed out by Eaton (3); navy bean showed 39% and 45% growth in isosmotic concentrations of chloride and sulphate respectively. But he mentioned that sulphate appeared to be about *half* as toxic as chloride to tomato and beet. Russel (15) however pointed out "peaches and beans are damaged by chlorides in soil solutions at osmotic pressures at which sulphates do not harm them." The present study indicates that with optimum water supply, gram is more tolerant to chloride than sulphate; but under conditions of soil drought, the chloride is more deleterious.

SUMMARY

Relative salt tolerance of gram (N. P. 58) was investigated in pot cultures with two doses of NaCl and Na_2SO_4 (0.05% and 0.01% on air dry soil) added to the soil. Five replications were maintained for each treatment including the control. From 8th to 12th week after sowing, the plants were subjected to permanent wilting condition four times by stopping watering. A control series with continuous optimum water supply was also maintained. Observations were recorded on germination, growth at four weekly intervals upto maturity, and also the yield and quality of the seed.

Germination was not affected by either of the doses of the two salts. Both chloride and sulphate affected growth adversely; chloride affected shoot-height, while sulphate was more deleterious to leaf and branch number. Under optimum water supply, shoot dry matter was reduced by 17.4% and 6.9% with the two doses (0.05% and 0.1%) of NaCl, and by 34.6% and 48.4% with those of Na_2SO_4. On the contrary, in plants subjected to soil drought, as compared to the control with optimum water supply throughout, it was reduced by 50.5% and 64.0% with the two doses of NaCl, and by 42.6% and 44.4% with those of Na_2S0_4. Soil drought alone reduced the shoot dry weight by 31.7%.

Yield could be recorded only for the optimum set. Compared to the control, it was lowered by 29.2% and 31.6% by the two doses of NaCl and by 49.0% and 55.3% by those of Na_2SO_4. The quality of seed was affected by the higher doses (0.1%) of the two salts and to a greater extent by Na_2So_4.

Sulphate seems to be relatively more toxic to growth of gram than chloride under optimum conditions of water supply. With soil drought during growth stage (8th to 12th week) relative toxicity of the two salts, NaCl and Na_2SO_4 (particularly the higher dose-0.1%), was reversed; the former salt resulted in a greater depression of growth.

Our thanks are due to Prof. S. Sinha, Head of the Botany Department, for facilities and for encouragement.

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*Original not seen.

STUDIES IN THE FAMILY VITACEAE

I.—FLORAL MORPHOLOGY OF *Vitis trifolia* LINN.

By GANDHARI KASHYAP, *Sophia Girl's College, Ajmer.*

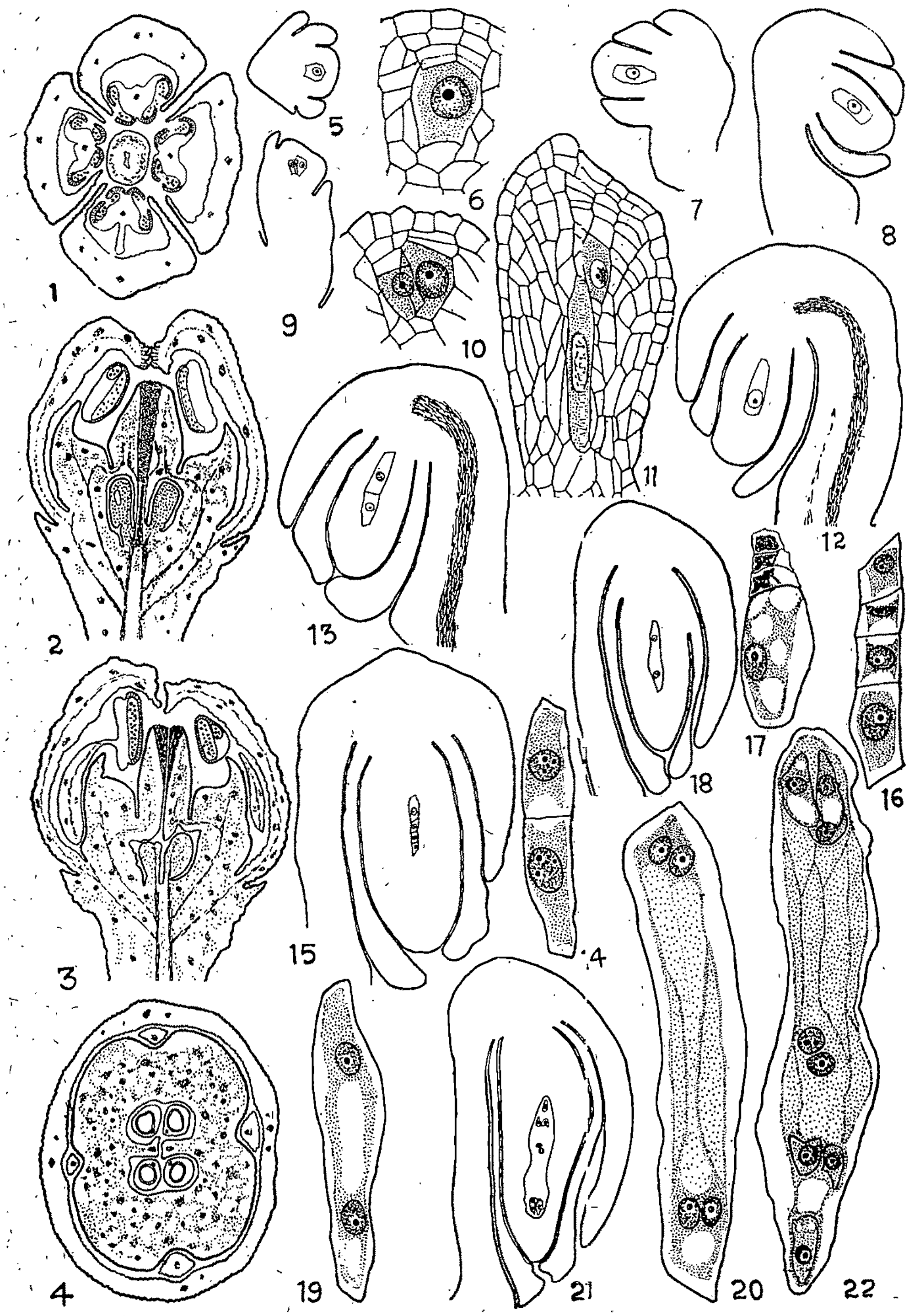
INTRODUCTION

A number of contributions on the genetics and parthenocarpy of the edible grape (*Vitis vinifera*) are available. Until very recently the morphology and embryology of Vitaceae have been greatly neglected. Adatia, Mulary and Hingorani (1, 2) contributed to the embryology of *Vitis trifolia.* Mulay, Nair and Sastry (4) described the gametophytes of *Vitis pedata.* Nair and Parasuraman (5) studied the gametophytes of *Vitis pallida.* The present study of the floral morphology of *Vitis trifolia* presents some interesting morphological features, not described so far.

MATERIAL AND METHODS

Conspicuous cymes of greenish-white flowers are usually axillary. The sepals are much reduced and represented only by a circular rim. Though flower is ,generally tetramerous pentamerous and trimerous flowers are also frequent. The petals are free, boat-shaped and accommodate the antepetalous stamens (fig. 1). The filament of the stamen is massive basally and tapering above. The narrow portion of the filament is more or less horizontal in the flower and is attached to the erect anther (fig. 3). Pollen grains are shed at the two-celled stage and endothecium shows the usual fibrous thickenings. Adatia, Mulay and Hingorani (1), however, report that the endothecial cells do not develop any transverse striations or fibrous thickenings. In *Vitis pedata* (4) and *Vitis pallida* (5) the pollen grains are shed at the three-celled stage and the endothecium shows the usual fibrous thickenings. The ovary wall is fused with the disk, which is raised around the gynoecium in the shape of a circular crown over the top of the ovary figs. (2, 3). The style is massive and the transmitting tissue is well-developed (fig. 2). Gynoecium is bicarpellary, the margins of the carpels are incompletely fused in the centre giving rise to an axile placenta (fig. 4). Each of the 2 Loculi has two anatropous ovules. attached somewhat basally. The greenish grape-like fruit is globose in shape and there are four seeds sometimes less by abortion. Histologically the wall of the fruit is made up of uniform parenchymatous cells and does not show any anatomical differentiation so characteristic of the pericarps of angiosperms.

The material was collected from the outskirts of Ajmer and was fixed at the spot, after being suitably trimmed to allow proper fixation. Formalin-acetic alcohol and Acetic-alcohol gave satisfactory results. The material was processed and embedded in paraffin wax in the usual way. The serial sections



For explanations see p. 783

of various thicknesses were cut and stained with Haidenhain's iron alum haematoxylin, safranin-fastgreen and gentian violet-crythrosin.

OVULE

Large funicle is a characteristic feature of the ovule (figs. 12, 13). It becomes inverted during the development of the megaspore mother cell (fig. 7, 8 and 12). A broad vascular strand extends upto the chalaza in the funicle (figs. 12, 13). The nucellus is crassinucellate and is developed as a result of divisions in the primary parietal cell as well as in the nucellar epidermis (fig. 11). As a result of this the megaspore mother cell becomes rather deep-seated in the nucellus. It is surprising that Adatia, Mulay and Hingorani (1) find that "the epidermis does not contribute to the formation of any of the parietal layers." The ovule is bitegmic, the outer integument is slow to develop and remains behind the inner, until after the embryo sac has fully formed. Afterwards, however, it grows beyond the inner integument and becomes a part of the micropyle along with the inner integument (fig. 31). Adatia, Mulay and Hingorani (2) record that "the micropyle is formed by the inner integument as the outer integument never extends beyond the level of the nucellus."

MEGASPOROGENESIS AND MEGAGAMETOGENESIS

There is an inconspicuous hypodermal cell which functions as the megaspore mother cell after cutting off the primary parietal cell (fig. 5, 6). Sometimes, there are more than one archesporial and megaspore mother cells lying one over the other or side by side (figs. 9, 10, 11). In *Vitis pallida* (5) also, occasionally ovules with two megaspore mother cells occur. The megaspore mother cell is a quite stable developmental stage and remains for a long time.

It divides meiotically twice to give rise to a linear tetrad of four megaspores (figs. 14, 15, 16). Usually the chalazal megaspore functions and develops further into the *Polygonum-type* of embryo sac, Maheshwari (3) (figs. 17-22). The embryo sac is perfectly normal with one egg, two synergids, two polar nuclei and three antipodal cells. The synergids are beaked as usual. Adatia, Mulay and Hingorani (2) however describe that the synergids never show well-developed beaks.

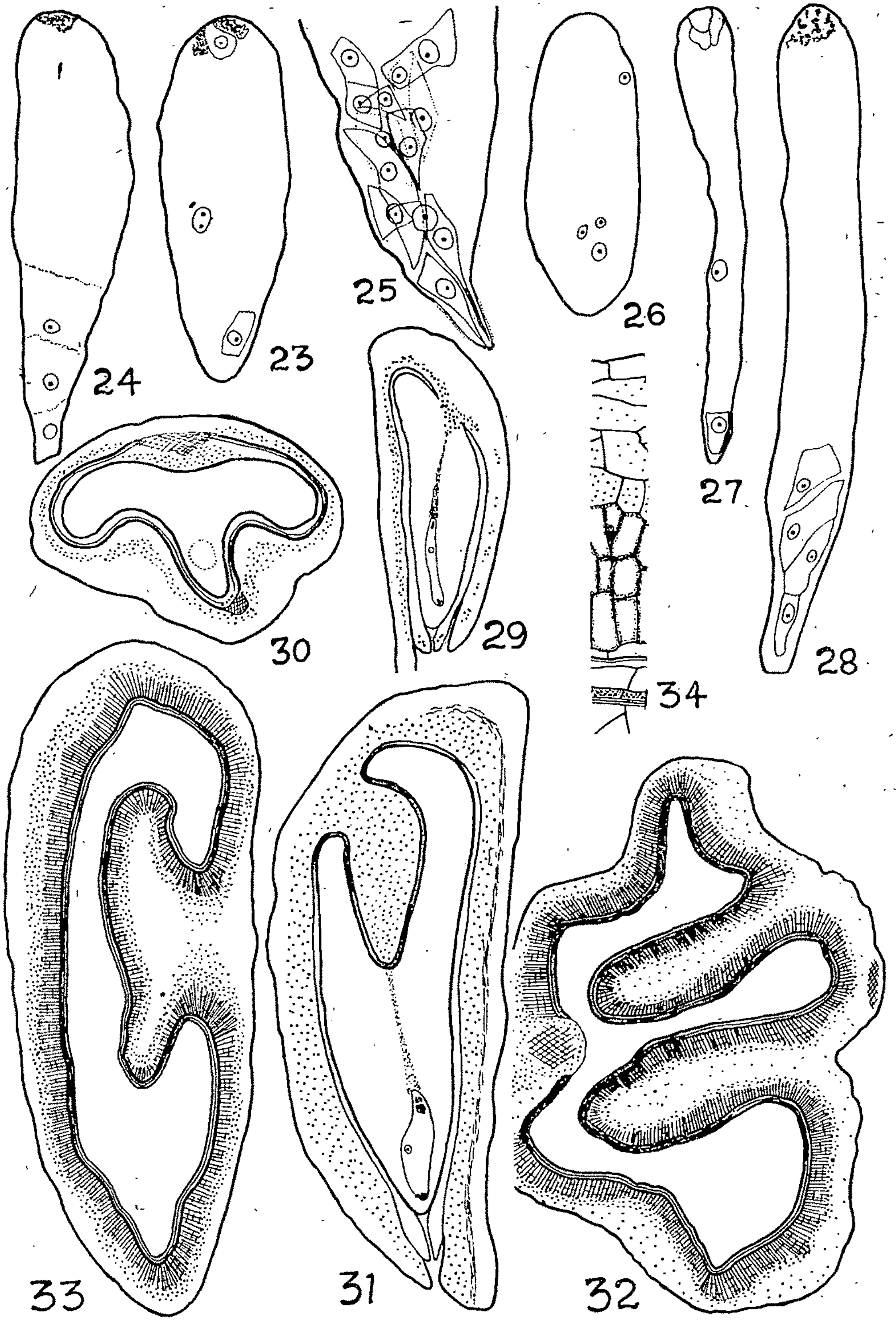
Vitis pallida it is reported (5) that the embryo sac comes out of the nucellus and the micropyle and establishes a nutritive relation with the ovary wall. Such an interesting behaviour of the embryo sac has not been observed in *Vitis trifolia*.

FURTHER HISTORY OF THE EMBRYO SAC

The egg apparatus invariably degenerates completely (figs. 24, 28). Sometimes the apparently healthy egg survives in between the degenerated synergids (fig. 23). It has never been seen to divide further. The polars may fuse giving rise to a large secondary nucleus (fig. 23). In most cases it degenerates and disappears rather early. Moreover, a nucleus from the nucellus may migrate into the embryo sac, enlarges and the position of the secondary nucleus and simulate it fully (fig. 27). It is not always possible to be sure of its real nature, whether it is the original secondary nucleus or a nucellar nucleus. It appears that the secondary nucleus may divide into two, three or four nuclei or the nuclei may be included in the embryo sac from the nucellus, appearing thereby as the division products of the primary endosperm nucleus (fig. 26). Eventually all these degenerate. The behaviour of the antipodals is more interesting, although fundamentally of the above type. Very frequently two antipodal cells degenerate quite early and the third, the chalazal one may survive as a haustorial cell, burrowing in the chalaza (fig. 27). Sometimes all the antipodal cells degenerate and a cell may descend from the nucellus, enlarge and take the place of the antipodal cell (fig. 23). More than one cell also come from the nucellus and may lose their protoplasm gradually, leaving behind the free nuclei at the chalazal end of the embryo sac. (fig. 24). These look unlike the antipodal cells. A large number of cells may also be included in succession at the chalazal end of the embryo sac. (figs. 25, 28). These have large and attenuated beaks which burrow very efficiently into the chalaza and seem to draw nourishment. In one case a little over a dozen cells have been counted (fig. 25). These cells simulate the antipodal cells in appearance and position, although they are clearly of the nucellar origin. Such haustorial 'antipodal' cells are triangular and drawn-out. They are large in size as compared to the nucellar cells and are richly protoplamic. Ultimately all activity ceases in the embryo sac and the cavity of the embryo sac becomes vacant. At this stage the embryo sac may collapse. Adatia, Mulay and Hingorani (2) have also observed the occurrence of supernumery nuclei at the chalazal end of the embryo sac but they think that the antipodal nuclei divide further to give rise to five or six nuclei which lie freely in a mass of cytoplasm.

THE SEED

The seeds are roughly triangular and have a wrinkled surface (fig. 32). At an early stage a conducting strand connects the chalaza to the chalazal end of the embryo sac (fig. 29). Afterwards a ridge grows in this direction from the chalaza, dividing the nucellus into two parts (fig. 31). Ridges also grow from the seed coat into the nucellus, as a result of which the nucellus assumes a corrugated appearance (fig. 30, 32, 33). The testa is about ten layer thick, the cells of the inner few layers are elongated and thick walled (fig. 34). The peripheral cells of the testa are full of darkly staining tannins. The tegmen is thin and feeble and lies in close contact with testa. Perfect seed coats are formed without fertilization. The seeds are ex-embryonate and the endosperm is not developed. The seeds in *Vitis vinifera* (6) develop nearly perfect seed coats without fertilization. Abortion of the ovules, however, is said to be due to mis-shaped ovule and defective embryo sac formation.



For explanations see p. 783

DISCUSSION

Adatia, Mulay and Hingorani (1) report that the endothecial cells in the wall of the another are without fibrous thickenings. I find, however, that the thickenings are present as usual, although not as prominent as in some of the angiosperms. The endothecial thickenings do not show much affinity to nuclear stains like haematoxylin and being refractive in nature, are difficult to observe unless stained with gentian violet or safranin.

It appears to be a feature of the Vitaceae that the nuclear epidermis contributes to the enlargement of the nucellus. This is very clearly the case in *Vitis trifolia*. Adatia, Mulay and Hingorani (2) however, maintain that the "epidermis does not contribute to the formation of any of the parietal layer." I am unable to offer any explanation regarding this difference in observation with mine of Adatia, Mulay and Hingorani (2).

The outer integument develops rather belatedly. However, after the formation of the embryo sac, it grows beyond the inner integument. The micropyle is thus formed first by the inner and ultimately by both the integuments. Adatia, Mulay and Hingorani (2) however describe that "the micropyle is formed by the inner integument as the outer integument never extends beyond the level of the nucellus."

Regarding the interesting behaviour of the antipodals, Adatia, Mulay and Hingorani (2) hold that the antipodal nuclei divide into five or six nuclei. My observations, on the other hand, show that the antipodals do not divide at all. All the three or two of the antipodals degenerate rather early. Further, the cells from the nucellus may migrate to the chalazal part of the embryo sac and occupy the position of the antipodals. The incoming cells may loose their cell walls, leaving behind the free nuclei or the cells may enlarge, remain intact and become haustorial and richly protoplasmic. I suspect that Adatia, Mulay and Hingorani (2) have not followed the origin of the five free nuclei, which they show in their fig. 26, and probably assume that they have come as a result of the division of the antipodal cells.

SUMMARY

The pollen grains are shed at the two-called stage and the endothecium shows the usual fibrous thickenings. Ovule is anatropous, crassinuceleate and bitegmic. Nucellar epidermis contributes to nucellus. Both the integuments take part in the formation of the micropyle. Development of the embryo sac is of the *Polygonum-type*. The contents of the embryo sac degenerate. The secondary nucleus and the antipodal cells are replaced sometimes by the nucellar nuclei or cells which eventually degenerate. The seeds have perfect seed coats but without endosperm and embryo.

ACKNOWLEDGMENTS

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EXPLANATION OF FIGURES

FIG. 1-22 Flower, Megasporogenesis and megagametogenesis.

FIG. 1. T. S. flower at the another region. Figs. 2, 3 L. S. flower in different planes. Fig. 4 T. S. flower showing the cross section of the ovary fused with the disk. Fig. 5. T. S. ovule, megaspore mother cell.

FIG. 6. The same more highly magnified.

FIG. 7, 8. L. S. ovules, megaspore mothercell. Fig. 9 young ovule showing two megaspore mother cells. Fig. 10. The same highly magnified. Fig. 11, Nucellus showing divided nucellar epidermis and two megaspore mother cells.

FIG. 12. Inverted ovule, megaspore mother cell. Fig. 13 ovule, dyad cells.

FIG. 14. The same highly magnified. Fig. 15 Ovule, tetrad of megaspores.

FIG. 16. The same highly magnified. Fig. 17. Functioning megaspore or the uninucleate embryo sac. Fig. 18. Ovule, two-nucleate embryo sac. Fig. 19. The same highly magnified. Fig. 20. Four-nucleate embryo sac. Fig. 21. Ovule, eight nucleate embryo sac. Fig. 22. The same highly magnified.

FIGS. 23-24 The seed and the further 'activity' of the embryo sac.

FIG. 23. Embryo sac showing egg, secondary nucleus and one 'nucellar antipodal.'

FIG. 24. The same, showing three 'nucellar antipodal nuclei.'

FIG. 25. Chalazal part of the embryo sac showing about thirteen 'nucellar antipodals,' the two lowermost much attenuated.

FIG. 26. Embryo sac with four nuclei, either the product of the primary endosperm nucleus or the nucellar nuclei.

FIG. 27. Embryo sac showing degenerated egg-apparatus, 'secondary nucleus' and one antipodal.

FIG. 28. The same, showing the degenerated egg apparatus and the 'nucellar antipodals.'

FIG. 29. Ovule, advanced stage, showing embryo sac as in Fig. 27.

FIG. 30. T. S. Ovule, advanced stage, showing ingrowths from the testa into nucellus.

FIG. 31 L. S. advanced ovule, showing the ridge at the chalazal region, the outer integument has outgrown the inner integument.

FIG. 32. T. S. seed showing seed coats and ingrowths from the seed coats into the nucellus.

FIG. 33. Same in L. L.S.

FIG. 34. T. S. a portion of the seed coats.

COMPARISON OF ACUTE TOXICITY OF THE COMMON ANTI-CONVULSANT DRUGS IN EXPERIMENTAL ANIMALS

By S. S. GUPTA, M. D., *Department of Pharmacology, M. G. M. Medical College, Indore.*

Since the introduction of hydantoin and oxazolidinedione derivatives in the control of epilepsy, a number of reports regarding their toxicity in experimental animals and human patients have been made (8, 9, 10, 13, 17). The widespread general use of the so called risk anticonvulsants-thiantoin sodium, mesantoin and tridione has been criticised, because of their certain severe toxic or even fatal reactions (4, 11, 12, 20). Recent report by Butler *et al.* (3) on the demethylation of mesantoin and tridione to more toxic compounds-5, 5, phenyl ethyl hydantoin (nirvanol) and 5, 5 dimethyl 2:4 oxazolidinedione respectively in the body has further raised a doubt in their general use. Moreover the comparative toxicity data in experimental animals are still insufficient so as to condemn these dangerous but otherwise valuable therapeutic agents. It was therefore thought necessary to compare their acute toxicity on the basis of mean lethal (L. D. 50) and toxic doses (T. D. 50) in different species of experimental animals.

MATERIALS AND METHODS

Anti-epileptic drugs sodium diphenyl hydantoin, (Dilantin sodium, Parke Davis); sodium 5, phenyl 5, 2, thienyl hydantoin (Thiantoin sodium, Illy Lilly) 3, 5, 5, ,methyl phenyl ethyl hydantoin (Mesantoin, Sandoz) and 3, 5, 5, trimethyl oxazolidine, 2: 4 dione (Tridione, Abbott), were supplied in pure powder form by the respective firms.

Fresh solutions of dilantin sodium and thiantoin sodium were prepared in distilled water and those of mesantoin and tridione in propylene glycol for intravenous and intraperitoneal injections in experimental animals.

A. *Determination of acute toxicity in pigeons.*—Pigeons weighing between 200-250 gms., were grouped in batches of five each with an equal average total weight in all the batches. One of the pigeon was stretched and the vein was made conspicuous by plucking the feathers of that region. Graded doses of drugs under investigation were injected into each batch of pigeons. Toxic symptoms and mortality were noted for each group. Mean lethal and toxic doses (L. D. 50 & T. D.) for each of the drugs used was calculated by Karber's formula:—log. L. D. $= \frac{XO(p_1+p_2)d.}{2}$

B. Determination of toxicity in dogs:—Young dogs weighing 3-4 kgm. were given doses of the anti-convulsants calculated as fractions of L. D. 50 doses for pigeons. Thus for dilantin, 125 mg. (1/5 of L. D. 50 approx)and 250 mg. (2/5 of L. D. 50); for thiantoin sodium 300 mg. (1/5 of L. D. 50) and 400 mg. (2/5 of L. D. 50); for mesantoin 450 mg. (about 2/5 L. D. 50) and for tridione 2700 mg. (2/5 of L. D. 50); were injected intraperitoneally. Toxic symptoms were observed for about six hours.

C. *Determination of acute toxicity in rats.*—Hydantoin derivatives were administered in graded doses from 50 to 375 mgs./kgm/body weight of albino rats grouped in batches of five each. Tridione was injected in doses of 250 mg. to 750 mg/kgm. into other batches of rats. These rats were allowed to move about freely on the table after the injections and were subjected to the following tests for determining the neurological deficit symptoms if any after these drugs. All these rats were previously subjected to the tests before selecting them for the experiments.

1. *Walking and postural test.*—Neurological deficit was indicated by unsteady circular, zigzag gait, ataxia, with abnormal speading of feet. Loss of rightening reflex was indicated by the inability to correct the altered position of the body.

2. *Positional sense test.*—When the hind limb of the normal rat was lowered along the edge of the table, it quickly lifted back to its normal position. Neurological deficit was indicated by the inability to correct the abnormal position of the limb.

3. *Vertical screen test.*—Control rats climbed easily a vertical screen having half inch mesh, where as the rats manifesting neurological toxic symptoms were unable to climb and maintain the position by holding the mesh work.

RESULTS

The percentage mortality in pigeons given the anti-convulsant drugs has been summarised in the table I, and the L. D. 50 doses are compared in table III.

The toxic effects after each drug varied with the dosage administered in the different groups of pigeons. Of the hydantoins derivatives dilantin sodium in 10 mg. per pigeon of average weight caused dizziness, muscular incoordination, nausea and vomitting with loose watery motion in most of the pigeons. Thiantoin sodium and mesantoin in equivalent doses produced only slight excitability, loss of equillibrium and gastric irritability, as evidenced by retching and vomitting. This dosage proved to be quite safe as none of the pigeons died in any group.

On increasing the dosage to 20 mg. per pigeon, head retraction, stiffening of the tail, muscular twitching together with ataxia were marked in pigeons given dilantin sodium (Pl. XXIX, fig. 1). In a few pigeons somersault movements and laboured breathing preceded death. Pigeons given thiantoin sodium and mesantoin in equivalent doses showed only slight irritability and muscular incoordination as evidenced by rolling movements. Drowsiness inturrupted by intermittant retching and vomitting was marked in pigeons given mesantoin and thiantoin sodium.

In other groups of the pigeons given higher doses (30-40 mg. per pigeon) of dilantin sodium instability, rigidity, exaustion and respiratory failure occurred in rapid succession before death. Thiantoin sodium and mesantoin in equivalent doses also caused signs of cerebral irritability-head retraction, nodding of the head, flapping of wings and muscular twitchings. Somersault movements were observed more frequently in pigeons given thiantoin sodium than those given mesantoin. Drowsiness and muscular paralysis with dropping of the neck were marked features of pigeons given mesantoin (Pl. XXIX, fig. 2).

On further comparing the effects of thiantoin sodium and mesantoin given in still higher doses of 50-70 mg. per pigeon, muscular incoordination and twitchings associated with air hunger were the common symptoms after these drugs. Intermittant retching and vomitting was more marked in pigeons given thiantoin sodium than those given mesantoin. The doses of 55 and 70 mg. per pigeons of thiantoin sodium and mesantoin respectively, proved fatal to all the pigeons of the other two batches.

Tridione in the comparative doses of hydantoin derivatives did not cause any toxic effect except that a few of the pigeons had dizziness and were seen to avoid bright light. However the doses of 50-150 mg. per pigeon of average weight caused symptoms similar to those of hydantoin derivatives, but irritability associated with tremor and rigidity was less marked. These symptoms were followed by prolonged drowsiness, inturrupted with intermittant retching and vomitting. Sensitivity to touch and pin prick was found to be absent as the dosage was gradually increased. When the dosage was further increased from 200 mg. to 450 mg./pigeon muscular paralysis especially of neck muscles associated with respiratory embarrasment were the marked symptoms before death.

TABLE I

Showing the ratio of the number of pigeon died and the number of pigeon injected with dilantin (Group-I). Thiantoin sodium (Group-II) mesantion (Group-III) and tridione (Group-IV).

Doses of hydantoins in Mg/pigeon while that of tridione in Mg. x 10/pigeon.

Dosage in mg/pigeon of aver. wt. (200.4 gm.)	Group-I $\frac{\textit{No. died.}}{\text{No. Inj.}}$	Group-II $\frac{\textit{No. died}}{\text{No. Inj.}}$	Group-III $\frac{\textit{No. died}}{\text{No. Inj.}}$	Group IV. $\frac{\textit{No. died}}{\text{No. Inj.}}$
10	0/5	-	-	0/5
15	2/5	-	-	1/5
20	1/5	-	-	2/5
25	2/5	-	0/5	2/5
30	3/6	-	1/5	3/5
35	4/5	0/10	-	3/5
40	5/5	3/5	1/5	4/5
45	-	3/5	-	5/5
50	-	4/5	2/6	-
55	-	5/5	-	-
60	-	-	2/5	-
65	-	-	3/5	-
70	-	-	5/5	-

Results in dogs given the hydantoin and oxazolidinedione derivatives given intraperitoneally have been interesting. Toxic symptoms in dogs given dilantin were indicative of affection of the central nervous system. Salivation, restlessness, dilation of pupil, unsteady gait, circular movements, delirium, intermittant nodding of head, as if in hallucinations, were the characteristic symptoms after 125 mg. doses. In dogs given higher doses retching, vomitting, frequency of micturation and loose motions, together with irregular breathing were observed. A few dogs given 250 mg. died after about 8 to 10 hours of injections, while those given smaller doses recovered after about 24 hours or so.

The toxic symptoms after thiantoin sodium were of milder nature. Salivation, drowsiness, retching, vomitting frequency of micturation were the marked symptoms. One of the dogs given 400 mg. of the drug had loose motions with blood and mucous. On the other hand the dogs given mesantoin looked drowsy, intoxicated, and were seen walking with ataxic gait. Some of these were found to crawl on the floor with the limbs wide spread (Pl. XXIX, fig. 5). These symptoms followed by drowsiness somnolescence and flaccid paralysis of neck and limbs, lasted for 5 to 6 hours, after which most of the dogs recovered.

Dogs given tridione also developed ataxia followed by flaccid paralysis of the hind limbs, which were seen dragging behind as they walked. Body sensations were found to be dulled as scratching of the skin with pin did not elicit any protective response. The state of drowsiness remined for about 3 to 5 hours, but muscular paralysis lasted much longer.

Results of toxicity in albino rats given the anticonvulsant drug has been shown in the table II as the ratio of the number of rats manifesting signs of neurological deficit to the number of rats injected. The mean toxic doses (T. D. 50) have been compared in the table III and the main toxic effects observed in each group given graded dosages are given below.

The different groups of rats given a dosage of 25 mg/kgm. body weight of the anti-convulsant drugs, were found to be free from toxic effects indicative of neurological deficit. Drowsiness, loss of rightening reflex and positional sense (Pl. **XXIX** Fig. 3), was observed in a few rats given 37.5 mg./kgm of mesantoin. Some of these were also found to be sluggish in climbing the vertical screen (Pl. XXIX, Fig. 4). In contrast to these, group I and II rats injected with equivalent doses of thiantoin and dilantin sodium, walked up freely over the vertical screen and only one rat out of five in group II developed loss of positional sense.

A dosage of 75 mg./kgm. of mesantoin rendered most of the rats incapable of performing in any of the tests, thus indicating marked neurological toxicity. On the other hand symptoms of intoxication, muscular incoordination with signs of nervous irritability as evidenced by circular movements with raising of the tail at right angles were observed only in a few rats of group I and II given equivalent doses of dilantin and thiantoin sodium.

The toxic manifestations in other batches of rats given even higher doses of 100 mg./kgm. of the anti-convulsants were more marked. Most of the rats injected with mesantoin were seen to walk or crawl on the floor with toes wide apart. These looked very sluggish and drowsy. Postural sense as well as protective response to scratching of pin were also absent. Thiantoin and dilantin sodium in similar doses also rendered majority of the rats ataxic and sluggish in performing the tests. Dyspnoea and retching were the marked features of the I and II group of rats. Positional sense and postural reflex was found to be completely abolished in rats given 125 mg/kgm of thiantoin sodium and 150 mg./kgm. of dilantin sodium. Muscular paralysis with dropping of the tail was the common feature in rats given high doses of mesantoin and thiantoin sodium, where as muscular twitching and nodding of head with clonic movements of fore limbs were frequently observed in rats given dilantin sodium.

As the therapeutic dose of tridione is about three to four times that of the hydantoin derivatives so a strict comparision in equivalent doses is not possible. The main toxic effects observed after intraperitoneal injections were given below.

Tridione upto 250 mg/kgm. doses in rats produced no toxic effects whatsoever, but signs of neurological deficit were observed in batches of rats given tridione in doses of 375 mg. to 500 mg./kgm. Inability to climb the vertical screen was shown by most of the rats, while the loss of positional sense and rightening reflex was exhibited only in rats given higher doses ranging between 625 mg. to 750 mg./kgm. of the drug. A dose as large as 875 mg./kgm. of the drug did not prove lethal to any of the rats but it certainly rendered all the five rats of the batch ataxic neurologically deficit in performing the tests. Drowsiness with dullness of sensation for touch and pain were also observed in few rats. Photophobia and dizziness were marked feature in this group of rats.

TABLE II

Showing the ratio of rats manifesting neurological deficit (N. D.) to the number of rats injected with dilantin (Group I). Thiantoin (Group II). Mesantoin (Group III) and Tridione (Group IV) Doses of hydantoins in mg./rat while that of tridione in mg. x 10/rat.

Dosage of anti-convulsants in mg/rat of aver. wt. 210 gm.	Group I *N. D.* No. inj.	Group II *N. D.* No. inj.	Group III *N. D.* No. inj.	Group IV *N. D.* No. inj.
5.0	-	-	0/5	0/5
1.5	-	0/5	1/5	1/5
10.0	0/5	1/5	2/5	2/5
12.5	-	-	-	3/5
15.0	1/5	2/5	3/5	4/5
16.0	-	-	-	5/5
20.0	3/5	3/5	3/5	-
25.0	3/5	3/5	5/5	-
30.0	5/5	-	-	-

The mean lethal doses (L. D. 50) in pigeon and toxic doses (T. D. 50) in rats the calculated from the above data by Karber's method have been summarised in the table No. III. The toxicity data in pigeons and rats have been compared in fig. 6.

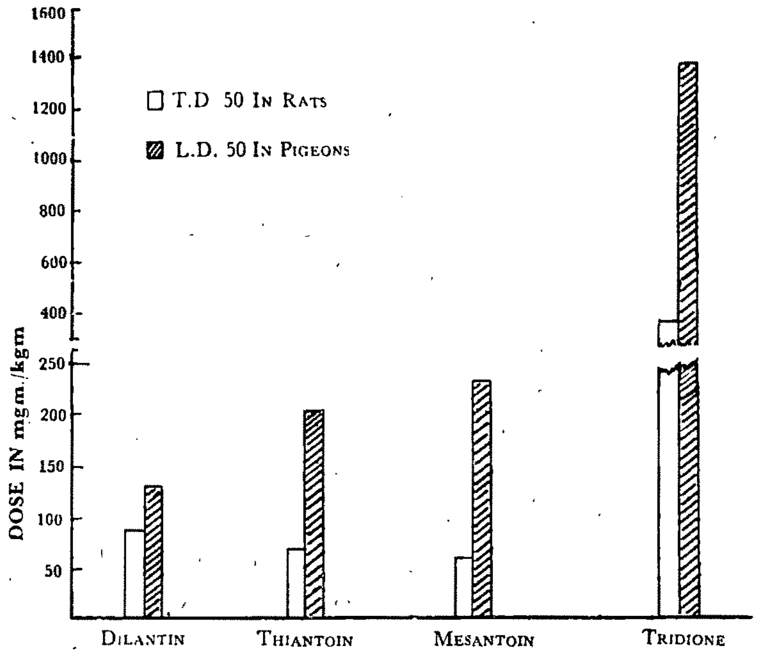

Fig. 6. Showing the comparative toxicity of the Anti-Convulsant drugs in pigeons and rats.

Table III

Showing the mean lethal intravenous dose (L. D. 50) in pigeons and mean toxic intraperitoneal dose (T. D. 50) in rats injected with anti-convulsants.

Group No.	Anticonvulsant drugs	Mean lethal dose (L. D. 50) mg/kgm. in pigeon.	Mean toxic (T. D. 50) mg/kgm. in rats.
I	Dilantin sodium	125.7	97.8
II	Thiantoin sodium	220.0	76.8
III	Mesantoin	250.0	65.02
IV	Tridione	1430.0	455.0

Discussion and Summary

Toxicity of hydantoin and oxazolidinedione derivatives used in epilepsy has been investigated by various workers in different species of animals. Gruber *et al.* (9) reported that diphenylhydantoin given to mice and rats in 75-300 mg/kgm. doses caused marked irritability, unsteady gait, jerky movements followed by cerebral depression and death. In the present investigation, interesting observations were made on pigeons and rats given the anti-convulsant drugs under discussion. Pigeons were found to be quite suitable for determining the intravenous toxicity of the drugs. Dilantin sodium in doses of 50-70 mg./kgm. caused signs of cerebral irritation as evidenced by head retraction, flapping of wings with arching of the tail in pigeons and nodding of the head, zig-zag circular movements in rats with their tail raised at right angles. Instability, somersault movements, muscular twitchings, followed by air hunger and death were the marked effects in pigeons given higher doses. Symptoms of cerebral irritability and clonic convulsion were less marked in pigeons after mesantoin and tridione as compared to either thiantoin or dilantin sodium. On the other hand mesantoin as well as tridione caused marked drowsiness, ataxia and muscular paralysis both in rats and pigeons. Similar effects were also noted in experiments with dogs. This difference in action of mesantoin and tridione on one hand and that of dilantin and thiantoin sodium on the other can be ascribed to the acidic and alkaline nature of the drug solutions, as the changes in pH have been known to affect the excitability of the brain (8). Further, the anaesthetics and sedative effects observed after mesantoin and tridione, in these experiment as well as reported by Butler *et al.* (2) and Richard & Everett, (14), might in part be responsible for masking the symptoms of cerebral irritability common to the other two hydantoin derivatives.

On comparing the mean toxic doses (T. D. 50) of these anti-convulsant drugs, mesantoin seems to produce toxic symptoms indicative of neurological deficit in comparatively smaller doses (T. D. 50 being 65.02 mg/kgm.) as compared to thiantoin and dilantin sodium (T. D. 50 being 76.8/kgm. and 97.8 mg/kgm. respectively). Swinyard *et al.* (18), however found mesantoins to be less toxic than dilantin on the basis of the oral and intraperitoneal T. D. 50 doses respectively in rats. As these anti-convulsants have been shown to influence the cortical steroid secretion (19) the toxicity of these drugs is likely to be affected by different routes of administration. In the present investigation where all these drugs were given intraperitoneally in rats, the marked toxicity of mesantoin may be attributed to its rapid demethylation to a more toxic compound nirvanol which is known for severe toxic and anaesthetic effects (2, 15). Moreover this difference in the toxicity of mesantoin in rats as compared with that in dogs and pigeons may be due to varying rates of demethylation in these species. The rate of production of nirvanol from mesantoin has been shown to be much lower in dogs than in rats ((Butler, 1953).

The lethal effect of these anticonvulsants was observed to be due to respiratory failure. Dilantin and thiantoin sodium were found to cause more respiratory embrassment as compared to mesantoin and tridione. This may be due to a direct or reflex action of dilantin and thiantoin sodium on the respiratory and other medullary centres producing clonic convulsions similar to those observed after metrazol. Ditantin has been found to increase glycogen in the cells of medulla in common with other convulsants (5). On the other hand mesantoin and tridione which have marked tendency to render the rats neurologically deficit might be acting on the higher cortical centres as also evidenced by their effectiveness in petitmal and psychomotor epilepsies (1, 13).

Though the toxic symptoms observed in experimental animals can hardly be applied as a whole to human patients, clinical reports corroborate most of these symptoms. One should not lose sight of these toxic manifestations while giving increasing doses of these drugs for controlling epileptic seizures. However it would be interesting to note that the initial daily therapeutic doses of mesantion (0.05-0.1gm.), thiantoin sodium (0.39 gm.), dilantin (0.3 gm.) and tridione (0.9 gm.) are more or less proportional to their T. D. 50 doses in rats so that the milder side effects can be avoided by careful regulation of the dosage. Moreover, the drowsiness which is responsible for limiting the functional activity in case of mesantoin and tridion is known to disappear with habituation (16). Further, the therapeutic efficiency ratio (i.e. the ratio of the $L.D._{50}$ pigeon to the human therapeutic dose calculated on the basis of body weight for 60 kgm man.) for mesantoin works out to be 75 as compared to 33.7 for thiantoin sodium and 25 for dilantin sodium in the series of hydantoin derivatives. Thus mesantoin has a fairly wide margin of safety in comparision to other two hydantoin derivatives. Similarly tridione which has a therapeutic efficiency ratio of 90.3 can be given safely to young victims. Thus these valuable agents can be used with advantage if the lesser toxicity of dilantin be combined with greater safety of mesantoin. Thiantoin sodium seems to have no special advantage either on dilantin or mesantoin.

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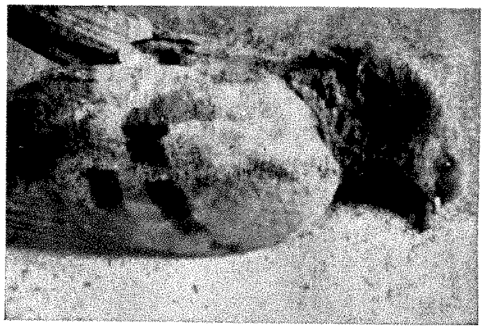

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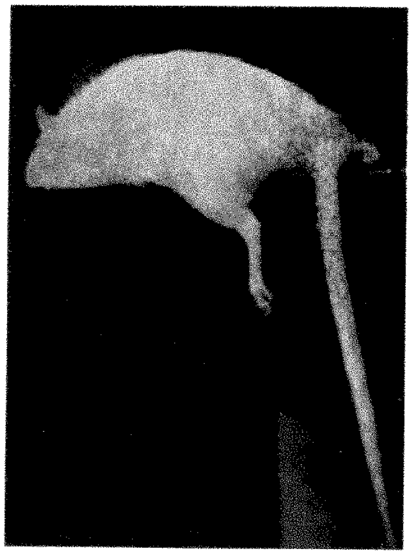

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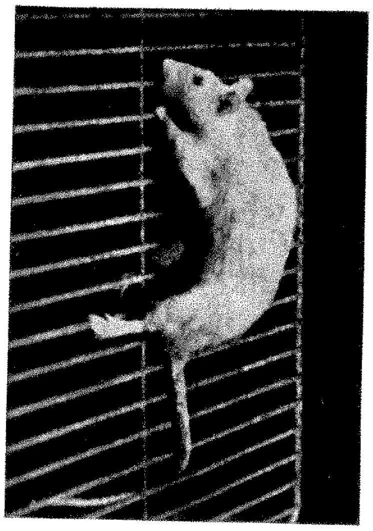

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PLATE XXIX

S. S. Gupta

1. Pigeon showing head retraction and arching of tail after dilantin 20 mg.
2. Pigeon showing muscular paralysis with dropping of the neck, after mesantoin 40 mg.
3. Rat showing loss of positional sense after mesantoin 25 mg./kgm.
4. Rat showing inability to climb the vertical screen after mesantoin 37·5 mg./kgm.
5. Dog crawling on the floor with the hind limbs wide spread after 450 mg. of mesantoin intraperitoneally.

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